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• • FAMOUS VICTIMS OF WATER BORNE DISEASES

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Vol. 28 JULY, 1936 **No. 7**

FROST DIFFICULTIES AND EXPERIENCES DURING THE PAST WINTER AT WILMINGTON

By W. Compton Wills

(*Chief Engineer, Water Department, Wilmington, Del.*)

Generally the Department had no frozen mains in the winter of 1936, although there were 15 broken cast iron mains due to the severe weather experienced; 120 services out of a total of approximately 27,000 were reported sufficiently frozen to require an extra effort to thaw; 1922 service complaints were answered comprising minor thawing, turning on and off for private repairs and sundry reasons; 79 services were repaired on the part of the City; 1160 frozen meters were removed, this number divided between 386 removed from cellar settings, and 774 removed from curb settings. There were no fire hydrants frozen.

The City experienced a frost penetration of 34 inches. You can all appreciate the joy this gave to the manufacturers of air compressors and the necessary accompanying equipment.

The cast iron main breaks for the most part were circumferential ones. Probably all of you join with us in wondering why these mains cannot pick a better time of the day to break rather than at five o'clock in the afternoon or during the early morning hours. It might even be opportune at this time to suggest to the cast iron pipe manufacturers in attendance that some improvement in the manufacture of this pipe be brought about to aid in having a more

favorable hour for such main breaks—or even better perhaps, to provide a real cast iron pipe, one that will not *ever* break.

SERVICES

The bulk of the thawing of services was accomplished with the Department's electric thawing outfit, with a generator delivering from 250 to 300 amperes and a voltage of between 10 and 15, thawing the ordinary city house connection in a very few minutes. The usual procedure was to attach one cable terminal to the brass stop just inside the cellar wall of the frozen service and the other terminal to outside spigot of the adjacent house if it has a supply—if it is frozen, to the corresponding stop in the cellar.

It was found that better results were obtained by clamping the terminal to the brass stop than to the iron pipe. In using the outside spigot, care should be taken to observe that the pipe to the spigot is not disconnected—such was the case in a few instances. It was also learned that whenever the meter was located in a pit near the curb, the application of hot water to the meter connections materially aided in the operation. If, as in two cases, the cellar is not heated and it is suspected that the pipes are frozen under the house, the terminal may be attached to the spigot furthest away from the point of entrance—usually the kitchen.

In outlying districts, where the houses are farther apart and where several mains exist in the same street, and accurate plan of the mains should be available. These records are being obtained, but are not as accurately known as they should be due to the City recently obtaining these parts of the system from private individuals who have not appreciated the necessity of such records. The private indviduals installing some of these rural services of the smaller sizes about Wilmington also have not appreciated the necessity of providing sufficient cover for them. Consequently, these mains are too close to the surface—less than our customary cover of approximately 4 feet—and were often frozen for a distance of several hundred feet. In one instance, there was a setup made which required the circuit to pass through over 700 feet of $\frac{1}{2}$- and 1-inch main, nearly half of which was believed to be frozen. This was thawed in $2\frac{1}{2}$ hours. In another instance, about 200 feet of frozen mains of the same sizes were thawed in $1\frac{1}{2}$ hours Upon another occasion the generator was run continuously $3\frac{1}{2}$ hours on approximately 200 feet of $\frac{3}{4}$- and 1-inch main without results. It was probably plugged by other than

an ice formation. The most discouraging part of thawing some of these services is the fact that many times we had to return to the same location to thaw out the same service again.

METERS

Wilmington has approximately 27,000 meters including about 3,000 curb settings. It is the rule to place responsibility for the loss of a meter located in the cellar and damaged by freezing on the property owner. The City assumes responsibility for the curb setting. The strict enforcement of collecting for the loss of meters in the cellar setting due to negligence on the part of the owners, we feel, has materially reduced the number failing at this location this year. It has been particularly noticed during the past winter that most of the meters damaged at the curb were caused by the lifting of the cast iron cover from the concrete meter tube. In many cases, this was done unbeknown to the Department by the various sidewalk contractors; in some cases by our own paving gang. It is anticipated that this can be remedied in the future. It was arranged that Department meter readers omit curb setting readings during the severe cold weather in order that the frost seal would not be broken. There were no unusual ways in which the meters failed. In the majority of cases, it was failure by loss of the frost proof feature. In a few cases damage was done to the gears.

FIRE HYDRANTS

We attribute the fact that no fire hydrants froze to the very capable manner in which our fire hydrant crew made the fall inspection of these hydrants. Following this inspection, we try to correct even the most minor fault in them. Particularly, do we follow up fires during the extreme cold weather and make sure that the hydrants are left in a perfect operation condition.

TREATMENT PLANT

Throughout the filter plant and reservoirs we kept a close watch on ice conditions. At the Hoopes Reservoir, back of the masonry dam impounding water to a depth of 100 feet, a groove was cut through the ice and kept clear when the thickness reached 12 inches. In one of the coagulation basins at the Rapid Sand Filter Plant, a scheme was utilized to keep the ice from lifting certain tie beams by providing an overflow keeping the water level at all times below a

dangerous point. At the Slow Sand Filter Plant the two acres of sand area are washed and raked by a Blaisdell Washing Machine. In order that this machine may be used during the winter months it was necessary constantly to pull the ice in thin layers to the front of the individual filter beds and there break it so that it would be melted by the filter influent. This was a daily operation and sometimes in extreme cold weather it was necessary to perform twice daily.

ORGANIZATION

There was nothing unusual about the organization of night crews, or the organization of the mechanics required to keep the equipment such as thawing apparatus, air compressors, automobiles, etc., in proper working order, during this period. Complaints tapered off considerably at approximately 11 P.M., following this hour the more serious break or complaints requiring immediate attention only were received.

We all know there is nothing much more unpleasant than a wet ditch on a cold snowy night with our old friend the lead furnace giving out its small amount of warmth and sticking by us as we search for the leak. This is a reminder that with all our troubles how remiss we would be without mentioning the splendid coöperation of our dependable crews throughout these trying winter periods.

(*Presented before the Four States Section meetings, April 23, 1936.*)

FROST DIFFICULTIES AND EXPERIENCES DURING THE PAST WINTER

By Carl A. Hechmer

(*Department Engineer, Washington Suburban Sanitary District, Hyattsville, Md.*)

The Washington Suburban Sanitary District, a metropolitan area adjacent to the District of Columbia, within the State of Maryland, contains approximately 104 square miles and serves a population of 75,000 with water and sewer service. At the present time there are 335 miles of water mains, 260 miles of sewers, 16,400 water services, all metered, and 12,600 sewer connections.

Water mains and services are laid in this District with a minimum cover of four feet and on all but a few services the meter is set in an outside housing at the property line. The system is 100 percent metered and the few remaining meters are set inside. The housing consists of a two-foot length of terra cotta pipe, 18 inches in diameter, upon which is placed a truncated cone of concrete, 18 inches high, 18 inches in diameter at the bottom and 15 inches in diameter at the top, with a 15-inch cast iron meter box frame and cover at the ground surface. The meter is set in a yoke 18 inches below the ground level. The effectiveness of this setting as a protection against frost is apparent from the small percentage of frozen meters during the past winter, which was unusually severe. A detail of the housing is shown in figure 1.

The extremely cold weather set in the last part of January and continued during the entire month of February with few warm days and long continuous periods when the temperature did not get above the freezing point. Frost penetrated to a depth of 30 inches below the ground surface in our District and the water system was considerably affected. A large number of complaints was received from people who had exposed plumbing or partially heated houses, and, of course, many vacant houses suffered frozen and bursted plumbing when the owners of the property failed to cut off the water supply and properly drain the pipes. However, such troubles were not

the responsibility of our District and repairs were made by plumbers, although we were called on to make a large number of emergency turn-offs for inside leaks when the property owner could not secure the services of a plumber promptly and damage to the property was being caused by the flooding water.

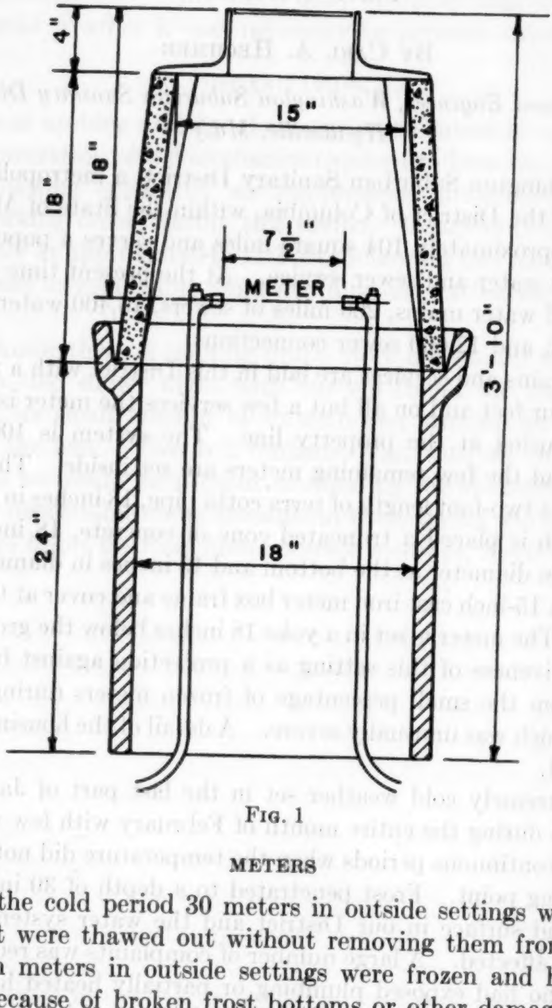

FIG. 1

METERS

During the cold period 30 meters in outside settings were found frozen, but were thawed out without removing them from service. Fifty-seven meters in outside settings were frozen and had to be replaced because of broken frost bottoms or other damage, and 14 meters were replaced in inside settings because of frost damage. Considering the fact that we have over 16,000 water meters in service, the small number of frozen meters speaks well for our type of setting,

for the temperatures at Washington were very low for long continuous periods. A daily record of the temperatures as recorded at our Burnt Mills plant indicates the extreme conditions experienced as shown in figure 2.

In every case of a frozen meter in an outside setting a special investigation was made to determine the cause of the freezing and failure of the housing to protect the meter adequately. In every case a defect was found which was corrected as soon as the weather moderated. For the duration of the freezing weather the meter was not reinstalled but was replaced by a piece of pipe, and the occupant of the house was instructed to allow the water faucet to run slowly during the night hours. The chief defects found were loose

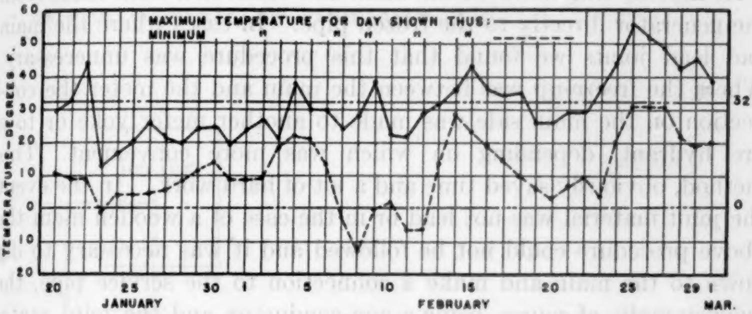

FIG. 2

tops, covers not properly locked, sides of housings exposed or broken by grading operations of the property owner, housings partially filled with earth, or the meter set too close to the lid of the housing. With the exception of the last defect all the others were caused by the work of the property owner in grading his lawn or front terrace after the installation of the service or since the last reading of the meter; otherwise the condition would have been reported by the meter readers and attended to promptly to prevent just such trouble as occurred. The last defect named is, of course, caused by the failure of the installation foreman to set the meter properly in the first place, or to the carelessness of the repair foreman in not lowering the meter yoke when changing the grade of the meter housing.

SERVICES

A total of 91 house service pipes was frozen by the deep penetration of the frost. When trouble was first experienced the thawing

was done by regular maintenance gangs with torches and wood fires, it being necessary partially to uncover the pipe or to remove a portion of the earth covering for almost its entire length. A total of 16 services frozen outside and 15 inside the property line was thawed in this manner. When the number of complaints increased and the cold weather continued an electric welding machine with a capacity of 300 amperes at 16 volts was secured from the Chicago Bridge and Iron Works, who were erecting a steel structure for us at Burnt Mills. The machine cost us $2.50 per hour including an operator, and resulted in a considerable saving in time and money in thawing service pipes. We were able also to take care of a much larger number of complaints per day and prompt service was possible.

At first we dug down to the main and connected both leads from the generator directly to the frozen pipe. In cases where the main had lead joints we found that this procedure was unnecessary. Where the freeze-up was between the main and the meter the connection on the main side was made to another meter yoke or to a fire hydrant, depending on which was more convenient. This method, obviously saved time and a lot of hard work. In the event the joint material was not lead or in the case of a wooden main the above procedure could not be followed and it was necessary to dig down to the main and make a connection to the service pipe, the wooden main, of course, being a non-conductor, and the joint material having such high resistance that it was impossible to get enough current to flow to heat the pipe. Moreover, there is grave danger of damaging the electrical wiring and even of starting a fire in the houses to which the services are connected, since the neutral wire of the electrical wiring of the house is grounded to the water pipes. This neutral wire is not fused, but is connected solidly to the neutral of the electrical secondary distribution system. (See figure 3.) This forms a low resistance circuit through the neutral wiring much lower than that of the main. The conductors are too small to carry the heavy current and disastrous heating may occur. In cases where the freeze-up was between the meter and the house the connections were made to the meter yoke and to a pipe in the house as near the point of entrance as possible. The connection to the piping or meter yoke was made by means of "C" Clamps.

From February 1 to 21, 60 services, 40 between the main and meter and 20 between the meter and the house, were thawed. Also a 2-inch main was thawed in Westmoreland Avenue, Takoma Park.

The time required, after the electrical connections were made, varied from three minutes to one and one-half hours, depending on the size of the pipe and the extent of the ice in the pipe. Two machines

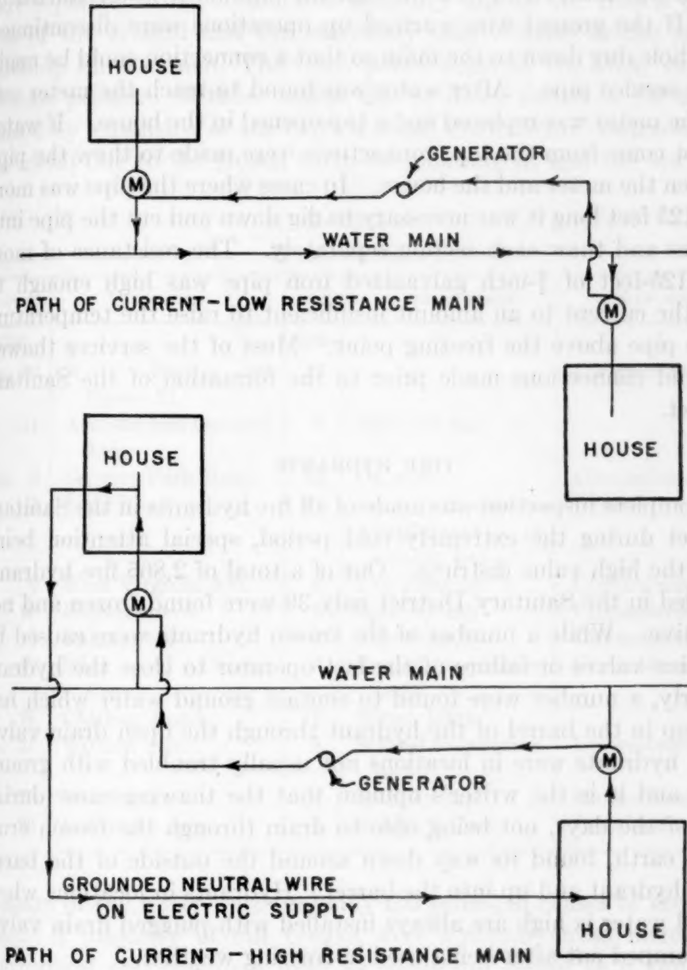

FIG. 3

were connected in parallel on the 2-inch main. The time required was five hours.

The procedure on arrival at the location was to remove the meter and determine if there was water at the meter. If not, connections

were made to this meter yoke and to an adjoining meter setting or fire hydrant, the generator was started and the ground wire in the house was watched for heat. If the ground wire did not heat the current was allowed to flow through the pipe until water started to run. If the ground wire warmed up operations were discontinued and a hole dug down to the main so that a connection could be made to the service pipe. After water was found to reach the meter setting the meter was replaced and a tap opened in the house. If water did not come from the tap, connections were made to thaw the pipe between the meter and the house. In cases where the pipe was more than 125 feet long it was necessary to dig down and cut the pipe into sections and thaw each section separately. The resistance of more than 125-feet of $\frac{3}{4}$-inch galvanized iron pipe was high enough to limit the current to an amount insufficient to raise the temperature of the pipe above the freezing point. Most of the services thawed were old connections made prior to the formation of the Sanitary District.

FIRE HYDRANTS

A complete inspection was made of all fire hydrants in the Sanitary District during the extremely cold period, special attention being given the high value districts. Out of a total of 2,865 fire hydrants installed in the Sanitary District only 39 were found frozen and not operative. While a number of the frozen hydrants were caused by defective valves or failure of the last operator to close the hydrant properly, a number were found to contain ground water which had built up in the barrel of the hydrant through the open drain valve. These hydrants were in locations not usually troubled with ground water and it is the writer's opinion that the thawing snow during some of the days, not being able to drain through the frozen crust of the earth, found its way down around the outside of the barrel of the hydrant and up into the barrel. Hydrants in locations where ground water is high are always installed with plugged drain valves and pumped out after being used in freezing weather.

Carbide was used to thaw the hydrants in all but a few cases, where fire was used around the barrel. Ordinary carbide such as is used in a carbide lamp was used. Several lumps placed in the hydrant on top of the ice will make a hole through the ice in a few minutes and once the flow of water is started the rest of the ice is easily removed. Care must be taken, however, to flush out all of the carbide after the hydrant is thawed.

BROKEN MAINS

During this period an epidemic of broken mains occurred. One 4-inch, five 6-inch, two 8-inch, and four 12-inch mains failed and were repaired with considerable difficulty due to the frozen condition of the ground and the extremely cold weather which caused hardship on the men. The deep penetration of the frost causing extreme pressure on these mains, due to down thrust in the trench caused by expansion of the earth's crust, the extreme contraction of the metal due to the frozen earth surrounding it, and the low temperature of the water were probably the principal causes of the fractures. A majority of our breaks were circumferential instead of longitudinal and fractures were as clean and round as if the pipe had been severed with a hack saw or pipe cutter. A number occurred at locations where taps had been made and an undue strain probably placed on the pipe by screwing up the corporation cock too tight. Other breaks were no doubt caused by faulty foundation and bracing, but all of the mains that failed had been in service a number of years and had survived several winters.

TABLE 1

Breaks in main's

DATE	LOCATION	SIZE	CAUSE OF BREAK	TYPE OF BREAK
1936		*inches*		
Jan. 30	W.-B. Blvd. and Pierce St.	12		Circumferential
31	Arundel and Luttrell Aves.	8	Split by tap	
Feb. 2	Garrett Park Road	12	On rock	Circumferential
3	Agar Road	12	Joint leak due to settlement in stream bed	
9	West Virginia Ave.	6	Tap close by	Circumferential
10	Hopkins Ave.	6	Split by tap	Circumferential
13	Oakmont St.	6	Tap close by	Circumferential
19	Sligo and Cherry Aves.	6	Settled foundation in fill	Circumferential
21	Chillum Road	12	Blown joint	
21	Willard Ave.	8	Settled foundation in fill	Circumferential
25	Oak Street	4	Split by tap	Circumferential
26	Lafayette Ave.	6	Bridge failure	Longitudinal

Difficulty was experienced in a number of cases in determining the exact location of the break since the thick frost crust prevented the water from appearing at the break, and our leak-locating instruments paid for themselves many times over during this trouble. In one case a main leaked at the rate of $2\frac{1}{2}$ M.g.d. for 36 hours before being located, although six scouts had been out looking for it. The water followed under the frozen earth and into a stream below the water and ice level. Another leak coming out of a meter housing was found to have been caused by a fire hydrant 50 feet away.

A tabulation of the water main failures is shown in table 1.

(*Presented before the Four States Section meeting, April 23, 1936.*)

UNPRECEDENTED LOW TEMPERATURES AND THEIR EFFECT ON THE CHICAGO WATER SUPPLY SYSTEM

By Loran D. Gayton
(*Acting City Engineer, Chicago, Ill.*)

We are living in a period of extremes—extremes in governmental ideas—extremes of hurricanes—extremes of floods—extremes of drought and extremes of temperature, both high and low. The water works man abhors extremes for, in one way or another, they all mean to him, trouble.

During the past few years, in the western part of our country, the water works man has had to meet a great scarcity of water and at the same time an unusual demand for that commodity. At the present time, in the Eastern and Southern part of the country, the waterworks executive and his forces are facing the other extreme—tremendous floods. The winter of 1933–34 was a tough one in the waterworks field, but before the memories of that winter had passed, the waterworks man was called upon to face the problems of an other unprecedented period of low temperatures in the first months of 1936.

At some future date we shall hear from our brethren to the east how they faced the torrents of water poured down upon them by swollen rivers and how they did their stuff and carried on.

Today we are concerned with the problems brought about by the period of extremely low temperatures during the first two months of this year and I have been requested to tell you something concerning the effect of that period upon the Chicago water supply system.

THE METEROLOGICAL FACTS

The following is taken from the monthly Meterological Summary of the U. S. Weather Bureau for February 1936.

"The month (February 1936) was remarkably cold, being the second coldest February of record. The period of abnormally cold weather began on January 19 and was practically continuous through February 22. Beginning with

the 21st day of the cold and continuing day by day until its termination at the end of 35 days, each successive one-day-longer period was the coldest of record. The 30-day period covering January 22 to February 20 was 5.4° colder than the coldest calendar month of record, January, 1912. On 22 days during the 35-day period the temperature fell to zero or lower, and the total number of days in December, January and February this winter with a temperature of zero or lower is 25. This latter number equals the record set in the winters of 1874–1875 and 1884–1885.

"An abrupt change to milder weather began on the 23rd, lasting four days, with the mean temperature averaging considerably above normal. Had only normal temperatures prevailed during this period, the month would have been the coldest of record, and the winter as a whole would have been the second coldest of record instead of the fourth coldest."

"The precipitation this month was only 61 per cent of the normal, but the snowfall, which was mostly of a dry character was four inches greater than usual."

TABLE 1

35 day below normal temperature period

Duration: From Sunday, January 19 to and including Saturday, February 22, 1936

Normal temperature (65 year average): Min. 23, Max. 28, Mean 29 degrees

January, 1936, temperature: Min −17, Max. 43, Mean 19 degrees

February, 1936, temperature: Min. −14, Max. 56, Mean 15 degrees

30 Day Period Temperature: Min. −17, Max. 33, Mean 7 degrees

January 19 to January 31, or 13 days had 138 hours of zero or below temperature

February 1 to February 22, or 22 days had 133 hours of zero or below temperature

January 19 to February 22, had 271 hours of sub-zero temperature, or 32.26 per cent of a total of 840 hours for 35 days

Paramount facts that stand out during the below normal record cold spell are enumerated below:

January had 9 days where temperature recorded was zero or less, or 29.03 per cent of total days (31) for month.

February had 13 days where temperature recorded was zero or less, or 44.83 per cent of total days (29) for month.

A 56 hour continuous sub-zero temperature was recorded from 6:30 a.m. on Wednesday, January 22 to and including 1:00 p.m. on Friday, January 24, with a maximum temperature of 17 below, from 7:00 to 8:00 a.m. on January 23, 1936.

A coincidence of continuous sub-zero temperatures, which started at the same hour of the days, and stopped practically at the same

time two days later, was recorded for a period of 37 hours from 8:00 p.m. on Saturday, February 8, to 8:00 a.m. Monday, February 10, also for a period of 39 hours, from 8:00 p.m. on Monday, February 17, to 10:00 p.m. on Wednesday, February 19, 1936.

Temperatures recorded on Tuesday, February 18 (−14.0) and Wednesday, February 19 (−7.0) broke all previous record for low, since 1871, for these particular dates in February. Minimum temperatures recorded Wednesday, January 22 (−17.0) and Thursday, January 23 (−17.0) broke all previous record for low, since 1897, for these particular dates in January. The all time record for low temperature in Chicago was recorded in December, 1875, being 23 degrees below zero. In January, 1909, −20.0, and in February, 1922, −21.0 was recorded.

SOIL CONDITIONS

The water distribution system of Chicago is laid in almost every kind of soil. There are parts in rock, clay, sand, filled ground, and also in various combinations of these soils.

For many years the standard practice has been to lay the small mains, 12 inches or under, with 5½ feet of cover. The larger feeder mains, 24 to 54 inches in diameter, have various depths of cover, depending on sub-soil conditions pertaining to utilities and sewers, but the least covering is about 2 feet.

FROST PENETRATION

The normal frost depth in the Chicago district is generally assumed as 2 feet 6 inches when temperature goes to zero, and 1½ inches additional for each zero or sub-zero day thereafter.

The daily mean temperatures for the first 18 days in January 1936, were about six degrees above normal, which is about 24°F. In all of these days, except one, the temperature had been above freezing, so that on January 19, it can be assumed that there was little or no frost in the ground. On January 30, the first frozen water pipe was found in Ridge Boulevard at Pratt Avenue. The frost at this time was 5 feet deep in sand and gravel soil. The mean temperature for the 11 days before January 30 was plus 3, while the minimum had been below minus 3 for 8 days out of the 11 days. Two of these 8 days being minus 17 degrees. The average frost penetration under these conditions had been approximately 5½ inches per day. Records show that in exactly the same conditions of soil

the frost had penetrated to 62 inches by February 7, and in the eight days before the mean temperature had been plus 8 degrees and on 5 of these days the minimum had been below minus 3 degrees.

In clay soil a frozen main was dug up at 30th St. and Sacramento Avenue on January 29, and the depth of the frost was recorded as being 4 feet 7 inches below the pavement. The frost penetration in this medium dry yellow clay, under pavement, was at the rate of 5½ inches per day from January 19, the day that the temperature started down from above freezing. On February 10 another hole was opened on this main at 31st St. and Sacramento Avenue, and the frost was recorded as 5 feet 9 inches deep. Apparently the frost penetrated an additional 2 inches in these 12 days.

TABLE 2

Depth of frost, February, 1936

South District
5 feet 2 inches deep in clay
5 feet in sand (Stewart Avenue, South of 12th Street)

Central District
5 feet 6 inches in clay
6 feet in sand

North District
5 feet in clay
6 feet in sand

FROZEN SERVICES

As a rule, in Chicago, water services are lead and are placed at a depth of approximately 5 feet, but in many sections where the water supply system was in use before the area was annexed to the city proper, services were placed with much less cover. It was in these latter locations that the first trouble occurred, and it was from here that we received the greater number of complaints.

In many cases where the service had enough cover for protection the trouble was due to an unheated basement. Regardless of any of the foregoing conditions, the City forces thawed out the service without argument.

FROZEN MAINS

During the extremely cold period about 50 sections of water main were found to be frozen. In such cases it was impossible to get

water even after the service was put in operating condition. These frozen sections were all small supply mains, 12-inch and less in diameter, where, during certain periods of the day and night there was little or no circulation.

As the temperature began to rise and the frost came out of the ground, many leaks in the above mentioned supply mains were discovered. At the present time evidence is developing that there are still many breaks in the above mentioned mains which must be taken care of.

FIRE HYDRANTS

The fire hydrants did not give unusual trouble during this winter. In the high value area the Water Pipe Extension Division sent a steam thawing outfit to each fire, and this outfit thawed any hydrants found frozen, and also was useful in thawing out frozen apparatus for the Fire Department. Some hydrants branches were found frozen and some complaints of split branches are still coming in. When branches were frozen and thawed out, the problem of keeping them from freezing again was a serious one, and in many cases, where the surface drainage would permit, the hydrants were left running slightly.

WATER METERS FROZEN FROM JANUARY 1, 1936 TO MARCH 31, 1936

During the past three months it was necessary to remove approximately 3,200 meters from service which were frozen. During 1933 there were only 897 meters frozen; 1934 there were 424 frozen; and 1935 there were 770 frozen.

The 3-, 4- and 6-inch meters which have cast iron casings, when frozen solidly, invariably crack. We also find that the measuring chambers are sprung. However, in a great many cases we are able to put them in shape again.

With others, when too badly damaged, the parts that are not affected are salvaged.

The larger meters of 3-inch and over frozen during the winter were those installed in meter vaults on emergency services and were kept shut off.

As a rule, the large meters in meter vaults will not freeze, but this year being an exception, the frost having gone down over five feet in the ground, accounts for this.

During the past winter many meters were frozen which were lo-

cated in meter vaults which in past winters had not given any trouble. This was caused by the fact that the frost penetration was so deep that it was below the bottom of the meter vault and therefore there was nothing to keep the vault heated in any way. This was very evident in basins where the hoar frost extended to the bottom of the basin.

EQUIPMENT USED IN THAWING

In its work of thawing out services, mains, hydrants and meters, the department used the following equipment:

No. 1—Portable gasoline-furnace fired boiler generating steam. We had 42 of these outfits generating steam at approximately 10 pounds pressure, each outfit attended by one plumber, one laborer, and one truck. (Used on services and meters.)

No. 2—Portable steam boiler on skids. We used two of these outfits, generating steam at approximately 10 pounds pressure, each outfit attended by one hoisting engineer, one plumber, and two laborers. This outfit is used in thawing out mains where a large quantity of steam is required for an extended period.

No. 3—Portable steam boiler on truck. We used four of these outfits thawing out mains and hydrants where a large quantity of steam was required. Steam pressure approximately 20 pounds. Each outfit was attended by one hoisting engineer, one plumber, three laborers, and a driver.

No. 4—City steam roller. We used two of these outfits where large quantities of steam was required, at approximately 20 pounds pressure, each outfit attended by one hoisting engineer, one calker, and two laborers.

No. 5—Gasoline motor-driven electrical generator on light truck. We used 21 of these outfits, generating direct current at 30 volts, 300 amp. Each outfit was attended by one inspector, one plumber, two laborers, one truck with welder.

No. 6—Commonwealth Edison Co. transformer and equipment trucks. We used ten of these outfits. Connection was made to the Company's high voltage lines (A.C., and the current stepped down to either 110 or 55 volts). They delivered from 300 to 500 amp. Each outfit was attended by one inspector, and one plumber from the City's forces, and one foreman, two drivers, and four line men from the C.E. forces. This outfit required two trucks.

COSTS

The following costs are for the period from January 23, 1936 to February 25, 1936, inclusive. These figures are approximate only, and may be changed considerably when the final tabulations are made, but they will give some idea as to the cost in dollars and cents to the City of Chicago of the recent extremely cold winter.

There were approximately 5400 services thawed out, at a total cost of about $101,000., or an average of approximately $18.00 each. This cost included all rented equipment, labor, material, and overhead.

There were approximately 2300 frozen meters removed and spreads installed, at a total cost of approximately $7100.00, or something over $3.00 each. It cost approximately $6,000 for thawing out frozen mains.

Over 4800 frozen fire hydrants were put in operating condition at a total cost of over $14,000.00.

Up to February 25, 1936, the recent cold spell cost the City of Chicago over $137,000. There is no doubt that before the entire system is again placed in the condition it was in last summer it will have cost the City close to $230,000.

The following figures, showing the cost of thawing services with different types of equipment, may be of interest. These figures are approximate only and give the cost of operation of the equipment only:

	dollars
Average cost per service by Commonwealth Edison Co.	19.43
Welding outfit	12.55
Steam outfit	7.20

CONCLUSION

All the foregoing work is carried out under the direction of Mr. B. W. Cullen, Superintendent of the Water Pipe Extension Division, of the Bureau of Engineering, and Mr. John Garrity, Assistant Superintendent. Great credit must be given to these men and the entire personnel of the Water Pipe Extension Division for the way in which they met an extremely difficult situation.

I am greatly indebted to Mr. W. B. Weldon, Assistant Engineer, Water Pipe Extension Division, for collecting and tabulating the information and figures in this paper.

It is understood that it is impossible to make a complete report at the present time, but this complete report will be available at a later date.

(*Presented before the Illinois Section meeting, April 10, 1936.*)

THAWING SERVICE PIPES

By Frank C. Ambsbary, Jr.
(*Superintendent, Illinois Water Service Company, Champaign-Urbana, Ill.*)

The frozen service troubles arising from the excessively cold weather this past winter, were viewed with much concern by operators everywhere. Knowing a review of the experiences and the recommendations of others would be of help to the writer, some time was spent in reading published articles on this subject and in gathering information from a small group of Illinois operators. The information collected has been of interest and value.

Electrical thawing seems to be rapidly replacing all other methods. It is fast, and requires a minimum of labor, but must be carefully handled or disaster might result. Because of the increasing popularity of this method, and the dangers present when large currents are used, this review will deal, in the main, with this method.

Three sources of energy have been used with success, and are here named in the order of their apparent popularity.

1. Gasoline engine driven generator (of welder type);
2. Transformers;
3. Storage battery (one reported only).

The current obtainable from the first two sources mentioned is theoretically limited only by the size of the generating equipment, and for apparatus used in thawing services, it is limited only by the requirement of the application.

Operators have experienced the difference in the length of time required to thaw services of different materials, which are of the same diameter, approximately of equal length and under apparently similar conditions. Assuming no gaskets or patent coupling in the line, and all other conditions alike, except material, the reason for one material permitting more rapid thawing than another is shown in table 1 which gives the resistance in ohms per milfoot for metals most commonly used in service construction. Bear in mind that because of the difference in the proportioning of various elements used

in making pipe, these values will vary. However, table 1 is accurate enough to service as a guide.

These figures should be kept in mind as an aid to the operator while thawing a service. For example, assume a wrought iron service is to be thawed, tapped onto a cast iron main through a lead gooseneck. The higher the resistance per milfoot, the quicker the material will heat up, at any fixed rate of current. In this hypothetical case, the cast iron will heat first, the lead gooseneck next, and the frozen wrought iron last. Lead melts at 327°C. Wrought iron and cast

TABLE 1

METAL	OHMS PER MILFOOT*
Copper	9.35
Steel	63.00
Wrought iron	82.80
Lead	123.00
Cast iron	684.00

* Resistance in piece of metal 0.001 inch in diameter 1 foot long.

TABLE 2

SIZE	WROUGHT IRON, STEEL AND LEAD	COPPER
inches	*amperes*	*amperes*
½	200	500
¾	250	625
1	300	750
1¼	450	1,000
1½	600	1,500
2	800	2,000

iron at approximately the same point, in neighborhood of 1500°C. If care is not taken the lead gooseneck will melt. This is not only possible, but has happened many times.

Interpreting table 1 in another way, to thaw out a service of each of these materials under absolutely the same conditions in the same length of time, a minimum current would be required in cast iron and a maximum current in copper.

In an article by Fred Sheppard in the issue of May 30, 1934 of Water Works Engineering table 2 is given, and repeated here because it clearly shows the current needed to thaw services of wrought iron,

steel and lead, compared with copper, in a period of, from 5 to 10 minutes.

Mr. Sheppard does not state how these results were obtained, nor does he recommend the use of such heavy currents. It is the experience of this writer that the smallest current compatible with expediency, is preferred, and if the current is not held down, damage to the water system and even to homes, might result.

Mr. Sheppard further states theoretically, "On smaller flows of current, the period of time required is inversely proportional to the square of the current. For example, with ½ inch service..., if it takes 200 amperes 10 minutes to thaw out..., at 100 amperes it would take 40 minutes."

The question arises, what rate should be used in thawing a service. A definite answer to this question cannot be given. However, as a guide, various statements can be made from the writer's experience that may be of value. Services have been thawed in a reasonable length of time using 200 amperes at 30 volts on wrought iron and steel, and at 400 amperes on copper. Because of the low melting point of lead, and its relatively high resistance, it provides quicker heating. The Hobart Brothers Company, manufacturers of electric welders, recommend a maximum current of 150 amperes with as low as 75 amperes preferred. This low rate of current would require a long time to accomplish the job, but the length of time required is compensated for by assuring no damage to the lead.

TABLE 3

WIRE SIZE, B AND S	CIRCULAR MILLS	OHMS RESISTANCE PER FOOT	SAFE CURRENT CARRYING CAPACITY (FOR PROLONGED USE)
			amperes
0	105,538	0.00009838	200
00	133,079	0.00007801	225
000	167,805	0.00006186	275
0000	211,600	0.00004906	325

For short periods of thawing, twice these flows may be employed.

The size of lead wires from generator to pipe lines is stressed by Mr. Sheppard in his article and table 3 is reproduced because of its importance.

Every operator has been asked how long a time is required to thaw

a service, which is reminiscent of the age old question, which yet has to be settled, "How long is a drink of water." Reports have come through which indicate a flow of water in 5 minutes, and others up to 6 and 7 hours. The length of time required is dependent upon the current available, the efficiency of the circuit, and the underground conditions peculiar to any specific installation. The heat generated by the flow of current through the pipe is dissipated by conduction to the surrounding soil, melting the ice and warming the water in the pipe. It would be impossible to predict, for example, the heat conductivity of the soil, or the efficiency of the circuit. The presence or absence of, for example, sand, cinders, clay, gravel, or boulders, all have a direct effect upon the heat conductivity of the soil. One

TABLE 4

Time required to thaw service pipes

SIZE	MATERIAL	LENGTH	Volts	AMPERES	TIME
inches		*feet*			
¾	Wrought iron	600	60	250	5 minutes
1	Wrought iron	600	60	300	10 minutes
1½	Wrought iron	600	60	350	10 minutes
2	Wrought iron	500	55	400	15 minutes
3	Wrought iron	400	50	450	20 minutes
4	Cast iron	400	50	500	1 hour
6	Cast iron	400	50	600	2 hours
8	Cast iron	300	40	600	4 hours
¾	Copper	400	40	500	30 minutes
1	Copper	400	40	600	60 minutes
1¼	Copper	300	35	600	60 minutes

man reported the difficulty encountered in a case where a boulder was in direct contact with the service pipe. The capacity of the boulder to absorb the heat generated, delayed the process of thawing.

The Engesser Electric Manufacturing Company, Inc. of Watertown, New York gives table 4, as a guide on the approximate length of time required to thaw service pipes.

Gasoline engine driven generators of the welder type are growing in popularity for the thawing of services. At Champaign-Urbana, the writer's father, developed the first one in use at that plant in the winter of 1917-18. How long this method had been used before that time, or who the originator was, could not be determined. This method, over others used, eliminates the necessity for laborious and

costly digging of frozen ground and a specially trained crew to make the primary connections on transformer equipment. The speed with which the welder may be hooked up, thaw the service and get away to the next job is in itself distinctive.

To find out the problems encountered, methods used, and policies

FIG. 1. The winter of 1917-18 brought the first real trouble from frozen service lines in Champaign-Urbana. The portable boiler to supply steam for thawing, proved too expensive and entirely too slow to render service to the consumers.

The electrical method was relatively new at the time, so Professor Fisk of the Electrical Engineering Department of the University of Illinois was called in to aid in setting up the equipment. An old Metz Automobile was recovered from the junk heap, a generator borrowed from the city of Chicago, the above picture showing the result.

After the stress of the winter thawing demands had passed, the generator was returned to the city of Chicago, and the Company purchased a 30 volt, 200 ampere generator and mounted it on the same chassis, which served until 1929.

followed in thawing service pipes, the writer used two sources, the Round Table discussion in the May and June, 1934, Water Works Engineering, and by circularizing a small group of operators in Illinois.

Each one of these sources will be reviewed separately, because of the difference in the questions asked and the time between question-

naires. A résumé of the answers in the Round Table discussion, on methods used and policy followed in allocating costs, is given table 5.

The persons answering the questionnaire used various methods in replying, which made tabulation rather difficult. However, with the information furnished table 6 is representative. It will be noted

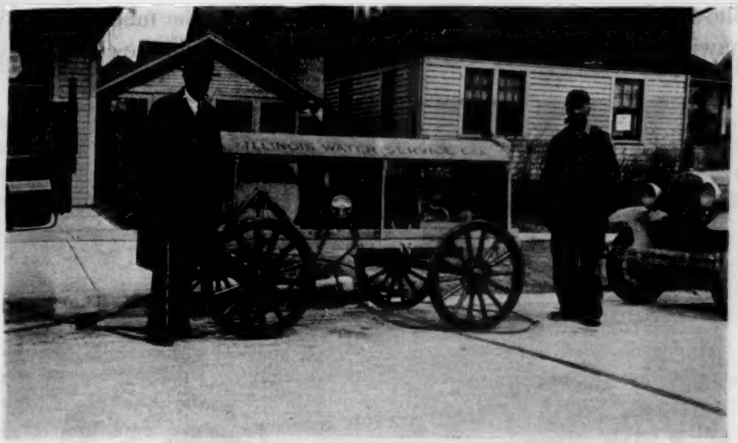

FIG. 2. There being practically no demand for equipment of this type until the winter of 1928–29, not much thought was given this outfit. Early in that winter the machine was rebuilt, still using the same Metz motor and the original generator. The above picture shows the results of this rehabilitation. It will be noted that the direct drive of the original set up was changed to a Multi-V-Belt drive, which allowed a more compact installation.

This served very well throughout this past winter (1935–36), but the old Metz motor breathed its last and the old wood wheels completely went to pieces. Consequently the outfit is now going through the third rehabilitation by the installation of a new Model A Ford engine and substituting wire wheels with pneumatic tires.

In a few weeks (4/7/1936) it will once again be ready for another 10 to 15 years of service.

that 9 reported electrical thawing, but did not specify the apparatus used.

Table 6 represents costs and charges. No distinction was made. Some of these figures represent the actual cost, while others represent the charge made to the water works by the person or firm executing the work, or the charge made by the water works, or third party, to the consumer.

The information received in reply to the questionnaire sent out by the writer is shown in table 7. There is no tie in, between the number of thawing units used, and the cost. For example, in some cases the thawing equipment was given, but no unit costs, and so on down the line. Not everyone answered the questionnaire in full. But the information as tabulated relative to the policy generally followed by water works throughout Illinois on the methods used in thawing, ownership of equipment, costs, who stands the cost of thaw-

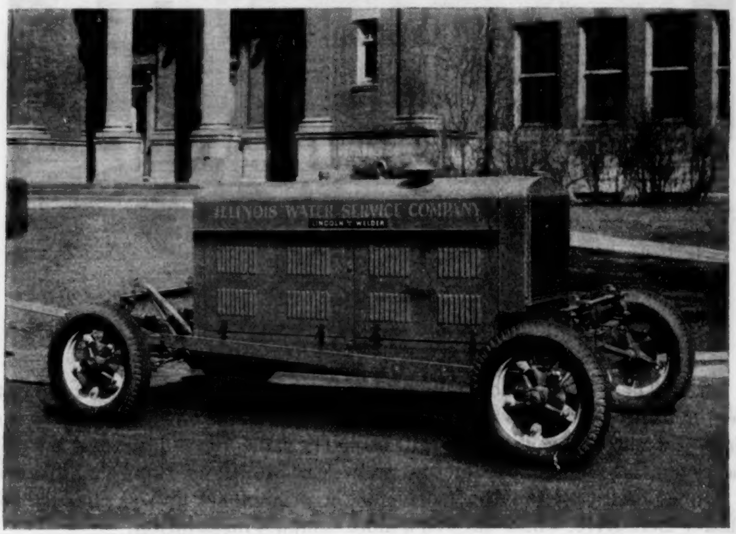

FIG. 3. At the height of the cold weather this past winter (1935–36), there were so many services frozen at one time that the company was completely snowed under, and being unable to render the service to which it was felt the consumer was entitled, the above welder was purchased.

This output of this welder is 150 to 600 amperes at 40 volts and was found to be very effective in thawing service lines.

ing, and responsibility of water waste to prevent refreezing is of interest, and value.

Who pays for the thawing of service? This is of great concern to the operator. In some cities the service is owned and maintained by the property owner only from the curb into the house. To determine the actual portion of the service frozen takes time. In winters like the past one, with others waiting for service, time is too valuable to waste in making an investigation. A few plants did take the

TABLE 5

Method of thawing

Transformer	19
Welder	11
Electricity	9
Steam	9
Hot water	5
Hot air	1
Battery	1
Consumer pays from curb in only	13
Consumer pays total cost	11
Water works pays total cost	11
Cost is split	3

Data from Water Works Engineering, May and June, 1934.

TABLE 6

Cost of thawing

TRANSFORMER	WELDER	ELECTRICITY	STEAM	HOT WATER	NOT CLASSIFIED
1—$1.45	1—$1.65	1—$3.50	1—$3.50	1—$7.00	2—$4.50
2— 2.50	1— 3.50	1— 9.50	1—50.00	1—10.00	2—15.00
1— 2.82	1— 4.77		to 60.00		1—20.00
1— 3.00	4— 5.00				1— 7.00
1— 3.37	1— 7.00				to 50.00
1— 5.72	2—10.00				
1— 5.50	1—15.00				
1— 6.20					
4—10.00					
3—15.00					
1—20.00					

TABLE 7

Methods used in thawing and ownership of equipment

Gasoline Engine generators (welder type)	20
Transformers	17
All other methods	4
Water works owned equipment	14
Water works did not own equipment	13

time to determine the point of freezing. It charged the property owner, if the service was frozen from the curb into the house, and the water works stood the expense if it was found to be frozen between

the main and the curb box. In other places the customer ownership extends to the main, in which case there is no doubt as to the responsibility.

Regardless of the extent of ownership of service pipes, a greater number of plants thaw at their own expense, rather than charge the consumer.

One plant making no charge for the first thaw reported a charge of $6.00 plus $3.00 an hour for every additional hour over two hours

TABLE 8

Varying costs

DOLLARS	WELDER	TRANSFORMER	OTHER
1.00 to 2.00	2	1	1
2.00 to 3.00	2	1	1
3.00 to 4.00	3	3	
4.00 to 5.00	4	1	
5.00 to 6.00			
6.00 to 7.00		1	1
7.00 to 8.00			
8.00 to 9.00	2*	1	1
9.00 to 10.00		1	
10.00 and over	3*	4	

* Rented equipment.

TABLE 9

Water works pays for thawing	12
Consumer pays for thawing	10
Cost is split in case of question of point of freezing, water works pays one half, property owner pays one half	2
Water works thaws once free, subsequent freezing paid by property owner.	4

when called back to thaw a service a second time, while another plant charges the consumer the cost on the second thaw.

Who pays for the waste when allowing the water to run after a service is thawed, to prevent refreezing? Most operators have wanted to know what policy other cities were following in this respect. Those answering the questionnaire furnished the information in table 10.

One city gives a written notice to the consumer at the time the thaw is made, which serves as his certificate of adjustment when payment of water bill is made.

"Do's" and "don'ts" of electric thawing taken from the answers to the questionnaire are as follows:

"Use smallest current possible to accomplish job, do not hurry by using heavy currents."

"Watch that you do not burn up connections between pipes or melt lead joints."

"Be sure to get good electrical contact at fire hydrant, curb box, etc."

"Be sure all ground connections are removed from the water pipe, and remove meter." Another removes the gas meter.

Not following this simple precaution has caused great damage and it is the writer's recommendation that the water meter always be removed. Failure to do this in one case caused a house fire by the current feeding back through a house circuit, which, of course, does not have sufficient capacity for such heavy currents. Another grave danger of not removing the water meter is the possibility of feeding

TABLE 10

Adjusts bill (no basis specified)	2
Water works pays excess	14
Consumer pays excess	8
Consumer pays excess only if service is frozen between curb and house	2

the current through the gas line by way of the water heater. This will probably melt the lead gaskets in the gas meter, creating a potential hazard.

"Conditions which should be guarded against, damage to electric meter (using transformer) rubber gaskets in fittings, using wire of proper size and design for the equipment, and not making connections through too short length of service line."

This last condition, thawing a short line, the current may be regulated by using a control in the secondary of the transformer, or on the output of the generator, either salt water or rehostats may be used.

"The particular condition we have come in contact with is the possibility of burning out lead goosenecks on the main . . . , used 500 amps. on 110 V circuit."

". . . Our experience showed it better to connect one cable to a hydrant instead of to the service pipe in an adjoining house. Heavy currents, . . . generally burning corporations, lead expansion joints or curb stops."

"It should be borne in mind, that when using the 110 V transformer . . . care

must be exercised that tight connections are made both on the water service and on the hydrant, and that the lead pipe or joints in the main are not damaged."

"We employ an electrician from . . . the power company to connect the thawing machine (transformer) with the, . . . distribution lines in the alley, instead of connecting a transformer with the switch box in the house, as the leads into the house are too small."

The question as to materials which withstand freezing the best, did not bring forth any information of value. Some reported lead and copper would not rupture, while others reported ruptures in both. It was unanimous that more trouble was experienced in steel and wrought iron than copper and lead, but the trouble here was due to corrosion by age leaving only a shell of a pipe which had insufficient strength to withstand the internal pressure caused by freezing.

THAWING MAINS

Although the questionnaire was confined to experiences with frozen services, three added some information relative to thawing mains. This is included here because of its close relationship to the subject of this paper, and because of its interest.

"We had two mains frozen. One was a short piece of dead end 6-inch pipe and the other perhaps 100 feet of 4-inch pipe. One of these thawing outfits (welder type) spent 18½ hours thawing these two mains at a cost of $45.64 for both including the time for our man and truck and the welding outfit and man."

"We had one 4-inch main frozen . . . thawed in ten minutes . . . electrical method . . . at a cost of $10.00."

"We had one 6-inch main frozen, dead end with one consumer . . . thawed in two hours . . . electrically at a cost of $20.00."

CONCLUSION

Special care should be taken to see that all connections are tight. Rust, scale, grease, etc., should be removed from the pipe at point of contact and the leads from the welding machine should be securely clamped in place. Ordinary "C" clamps are generally used for this purpose, although some users bind the cable to the pipe with copper wire. If connections are not tight, arcing may result in holes burned in the pipe. Furthermore, loose connections waste energy and slow up the thawing operation.

While some users report that they find it best to connect the positive lead from the machine to the point nearest the frozen section,

others have reported instances where the ice nearest the negative lead connection thawed first. It would appear, therefore, that this depends largely upon local conditions and that it does not really make much, if any difference, how the leads are located for polarity.

Gas pipes, etc. should be checked to see that they are not in contact with the water pipe. It does not take long to remove such hazards and the customer should not object to the slight extra time required to take such safety precautions.

The higher the current that can be safely used in the circuit the quicker the job can be finished. Care should be taken, however, to keep the current value within safe limits. Continually check connections and joints to see that they are not overheating. Also be careful not to put a severe overload on your welding machine for too long a continuous time.

(Presented before the Illinois Section meeting, April 11, 1936.)

REDUCING THE COST OF OPERATING CENTRIFUGAL WATER WORKS PUMPS

By A. Peterson

(Chief Engineer, Pump and Compressor Department, De Laval Steam Turbine Company, Trenton, N. J.)

At the 1933 Annual Meeting of the American Water Works Association in Chicago, I presented a paper entitled "Twenty Years' Progress in Centrifugal Water Works Pumps," in which I showed how much the efficiencies of centrifugal pumps had been increased during the preceding twenty years, amounting to from 15 to 20 percent on small pumps and from 8 to 10 percent on large pumps, and pointed out that considerable savings in operating costs could be realized by scrapping old pumps and installing new ones of up-to-date design. I also mentioned the considerable improvements that had been made in steam turbine driven pumps, due to an increase in Rankine cycle efficiency of the steam turbine of practically 20 percent during that period, and the fact there was a tendency to come back to this type of drive. Means for maintaining initial efficiencies, such as labyrinth rings, were also discussed.

As brought out in the 1933 paper, the centrifugal pump has now reached such perfection that further appreciable improvement in efficiency can hardly be expected. In confirmation of this I might cite a 55 m.g.d. pump operating against 160 feet head right here in Baltimore, which on the official acceptance test gave a pump efficiency of 90.7 percent and an overall efficiency of pump and motor of 88 percent. It looks, therefore, as if not much can be said on the subject suggested and selected for this paper, at least not in regard to new installations. In a way this is true, but some points can be presented which may be of benefit to the water works engineer or at least will give him something to think about.

In selecting equipment for his pumping station, the water works engineer has many difficult problems to consider. Not only is the choice between steam, electric power or Diesel drive sometimes very bothersome, particularly when, as is often the case, strong pressure

is brought to bear upon the engineer to induce him to select equipment that is not always the most economical or to the best interest of the taxpayers, but we also have another important point which is often neglected, and that is whether or not due consideration is given to the variations in operating conditions which occur in most water works plants, especially in those of the direct pumpage type. The pumping capacity must always be sufficient to meet maximum demand, including fire service. If it were a question only of variation in capacities, a sufficient number of units could be provided to obtain fairly efficient operation over the entire range, but we have also variation in pressures, which on account of the inherent characteristics of a centrifugal pump, presents a more difficult problem. In published articles on selection of pumping equipment, comparisons are often made on the basis of only one operating condition or else on the basis of variation in capacity at constant head, while if the comparison were to be made on the basis of *actual* operating conditions, including variations in head, an entirely different picture would present itself.

The only way to vary the output of a centrifugal pump efficiently, be it in capacity or in head, or in both, is by speed variation. If the savings in cost of pumping that could be realized by speed variation were more generally appreciated, steam or Diesel drive would in many cases appear more attractive than constant speed electric motor drive. It is my desire to avoid partisanship in favor of steam or Diesel drive, but I am convinced that for many pumping plants electric drive would not have been selected, particularly not for those of moderately large size, if a comparison had been made on the basis of actual operating conditions. The purpose of this paper is to present, briefly and for the sake of discussion, the savings which can be realized by adopting variable speed drive for centrifugal pumps, whether driven by electric motors, by steam turbines, or by Diesel engines. Steam turbines and Diesel engines are, of course, inherently variable speed prime movers and variable speed involves no special problem or expense.

The alternating current motor, on the other hand, is different. Practically the only type of variable speed induction motor used is the slip ring motor with resistance control. Reduction of speed with this method of control results in an appreciable loss of efficiency, but as I will try later to show the additional cost of variable speed may be warranted in spite of the lower motor efficiency. Pole-

changing to obtain variable speed is not as a rule practicable, since it can make only great steps in speed. The brush-shifting type of A.C. motor, which gives high efficiency with variable speed, apparently has not been developed to an extent that warrants its general use.

The synchronous motor, which now is used extensively in water works plants, offers no possibilities of speed variation, but a device has been introduced during the last few years by which the speed of the driven machine can be varied while the driver runs at constant speed. I refer to the variable speed hydraulic coupling, which has been used extensively in Europe and of which many installations have also been made in this country, mainly for obtaining variable output from centrifugal fans. Losses of the order of the slip of the coupling are associated with its use, but in view of the fact that the horsepower required by the centrifugal pump under certain conditions is reduced in the ratio of the cube of the speed, use of the hydraulic coupling on a variable load saves in power input to the motor.

VARYING OUTPUT

We, accordingly, have the following practical methods for varying the output from a centrifugal pump, all of which offer considerable savings in power or fuel as compared with throttling the pump discharge.

1. Steam turbine drive
2. Diesel drive
3. Variable speed motor
4. Constant speed motor with variable speed hydraulic coupling

The best way to illustrate what can be accomplished by speed variation is to take a concrete example and by curves show the characteristics of the pump under various operating conditions. Let us assume that the maximum daily pumpage is 10 m.g.d. against a total net head of 100 pounds per square inch, or 231 feet, and let us further assume that friction losses to a selected center of distribution amount to 75 feet and that it is desired to maintain a pressure of 231 − 75 = 156 feet at this point irrespective of delivery. Friction losses vary approximately as the square of flow, which means that at one-half flow, or 5 m.g.d., the friction losses would amount to approximately 75/4 = 18.75 feet, so that at half capacity, the total head required to be developed by the pump is only 156 +

18.75 = 174.75 feet. These figures show that where we have the variations just stated it would not be practical to install, say, two constant speed, 5 m.g.d. pumps designed for 175 feet head, because they would not be suitable for operation in parallel at a rate of 10 m.g.d., on account of the increased friction losses. An alternative would be to install, in addition to the two 5 m.g.d. pumps, a booster pump to take care of the increased friction losses at 10 m.g.d., but the scheme of using a 10 m.g.d. variable speed pump will be more attractive. Figure 1 shows the characteristics of the 10 m.g.d. pump, both at constant speed and at variable speed, to produce the required system head at different rates of flow down to 5 m.g.d. The savings in power input to the pump realized by using variable speed amount to 103 horsepower, or about 34 percent, at 5 m.g.d. delivery.

The user of the pump, naturally, is not so much interested in saving in power input to the pump as in saving in input to the driver, be it electric motor, Diesel engine, or steam turbine. In spite of the comparatively great saving in power realized by variable speed motor drive, a still greater saving proportionately is obtained with variable speed turbine drive, since the efficiency of the turbine drops less at reduced speed than does that of the A.C. slip ring motor or that of the constant speed motor with a variable speed coupling. There are, therefore, probably many installations in which steam or Diesel power will show greater economy than electric drive if the analysis be made on the basis of actual operating conditions rather than at one rate of delivery.

Based upon the characteristics of the pump shown in figure 1, additional curves are shown in figure 2 to show the kilowatt input to the motor at constant and at variable speed of the pump as obtained by speed variation of the motor and also by a hydraulic coupling. The overall efficiencies of pump and motor based upon the system head are also indicated for the different combinations. Figure 3 shows the total steam consumption in pounds per hour of a steam turbine driven unit, and the fuel oil consumption in pounds per hour of a Diesel engine driven pump.

As shown by these curves, the input to the motor of the constant speed pump when operating at 75 percent capacity is 16.6 percent less and at 50 percent capacity, 33.8 percent less than at full capacity. The corresponding amounts for the pump driven by a variable speed motor are 26 percent, and 47.4 percent, respectively, and for the pump driven through the variable speed hydraulic coupling 26.3

percent and 47.4 percent respectively. Because of losses in the hydraulic coupling, the input to the motor driving the pump through the coupling is at rated capacity 10.5 KW greater than to the motor

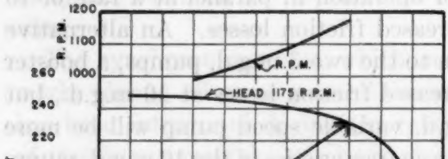

FIGURE 1

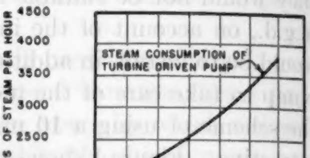

FIGURE 3

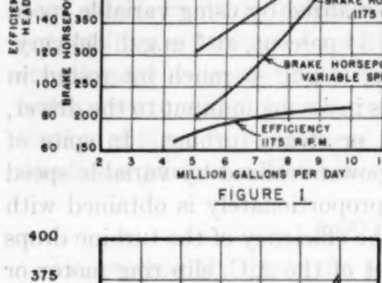

FIGURE 2

A = CONSTANT SPEED SYNCHRONOUS MOTOR

B = VARIABLE SPEED SLIP RING MOTOR

C = CONSTANT SPEED SYNCHRONOUS MOTOR WITH VARIABLE SPEED HYDRAULIC COUPLING

D = OVERALL EFFICIENCY-BASED UPON SYSTEM HEAD-CONSTANT SPEED PUMP

E = OVERALL EFFICIENCY-VARIABLE SPEED SLIP RING MOTOR

F = OVERALL EFFICIENCY-VARIABLE SPEED PUMP-HYDRAULIC COUPLING

driving the constant speed pump, but rapidly drops below the latter at reduced deliveries. Assuming that during a year's operation, the average demand corresponds to 75 percent capacity, which is

probably not very far off for a direct pumpage plant, the hydraulic coupling unit would realize a saving in current of 306 − 278 = 28 KW. If the cost of current is 1 cent per kw/hr., the yearly saving would amount to 0.28 × 24 × 365 = $2453. This sum would justify a considerable additional investment to obtain the variable speed. The fact is that the cost of the coupling in this case would not be very much greater than the annual saving in cost of current. This

TABLE 1

M.G.D.	HEAD	PUMP EFFICIENCY	B.H.P.	R.P.M.	MOTOR EFFICIENCY	EL.HP	KW	OVER-ALL EFFICIENCY SYSTEM HEAD
Constant speed pump—Synchronous motor								
10	231	87	467	1,200	94.7	493	367	82.5
7.5	242	82.5	386	1,200	94.17	410	306	63.9
5	246	71	304	1,200	93.37	326	243	47.1
Variable speed—Induction motor								
10	231	87	467	1,175	93.25	501	373.5	81
7.5	198	84.5	308.5	1,067	83.4	370	276	70.5
5	175	76.5	201	990	76.3	263.5	196.5	58.4

Synchronous motor—Variable speed hydraulic coupling

M.G.D.	HEAD	PUMP EFFICIENCY	B.H.P.	R.P.M.	COUPLING EFFICIENCY	MOTOR OUTPUT	MOTOR EFFICIENCY	EL.HP	KW	OVER-ALL EFFICIENCY SYSTEM HEAD
10	231	87	467	1,175	97.5	479	94.75	506	377.5	80.3
7.5	198	84.5	308.5	1,067	88	350.5	93.86	374	278	70
5	175	76.5	201	990	81.5	247	92.65	267	199	57.6

example, therefore, shows that even in cases where there is less variation in head or where the cost of current is less than assumed, it will pay to investigate carefully the savings in operating costs that can be realized by adopting variable speed drive for the pumps.

As may be noted from figure 2, the kilowatt input to the variable speed slip ring motor is slightly less than to the synchronous motor with variable speed hydraulic coupling, the difference being 2 KW at a pumping rate of 7.5 m.g.d. This saving is, however, offset by the low power factor of the variable speed slip ring motor. At 10

m.g.d. rate the power factor is 90, at 7.5 m.g.d. it has dropped to 87 and at a rate of 5 m.g.d., the power factor is only 82. The low power factor of the variable speed slip ring motor is probably one of the reasons why variable speed electric drive has not found a greater application in the water works field.

The hydraulic coupling, however, has made it possible to obtain the benefits of variable speed of the pump and at the same time permits the use of the synchronous motor with its power factor correcting features, thereby earning a considerable reduction in the unit rate charged for current. The coupling further lends itself to automatic control of the pressure, either at the pumping station or at some remote point.

In case you may not be familiar with the hydraulic coupling, I will give a short description of it. It consists simply of two radially vaned discs of saucer-shape, one keyed to the motor shaft and the other one to the pump shaft. Through circulation of oil by centrifugal force, power is transmitted from the impeller to the runner, there being a slip of about 2 percent when the coupling is full of oil. By reducing the amount of oil in the coupling, the slip is increased, so that practically any speed of the driven member can be obtained. The oil is removed from or admitted to the coupling through a stationary scoop tube. Simple regulating means can be used which will automatically control the amount of oil in the coupling, so that constant pressure will be maintained irrespective of the delivery of the pump.

As may be seen from figure 3, at 75 percent capacity, the steam and Diesel inputs are reduced 29.4 percent and 28.8 percent, respectively, and at 50 percent capacity, 49.6 percent and 51.5 percent, respectively, below the consumptions at full capacity. These figures are to be compared with 26.3 percent at 75 percent capacity and 47.4 percent at 50 percent capacity for the motor driven pump with hydraulic coupling. Both the steam turbine driven pump and the Diesel engine driven pump, accordingly, give somewhat better comparative performance at partial capacities than does the variable speed electric motor driven pump, and naturally considerably better performance than does the constant speed electric motor driven pump, for which the reductions in kilowatt consumption at 75 percent and 50 percent capacity are only 16.6 percent and 33.8 percent, respectively. It is, therefore, very important when analyzing the

merits of different kinds of drive not to confine the investigation to one operating condition only.

HIGHER STEAM PRESSURES AND TEMPERATURES

While on the subject of steam and Diesel drives, I should like to emphasize the considerable savings in operating costs that can be realized by adopting the higher steam pressures and temperatures which are now becoming common, not only in central stations but also in industrial plants. Not only should these higher pressures and temperatures be considered for new plants, but in old plants where turbine driven pumps and other equipment are still in good condition and additional pumping capacity is required, installation of a high pressure boiler and pumping unit, with the turbine exhausting into the existing low pressure steam main, may offer a very economical solution. Such practice is being followed in many central stations and industrial plants.

TABLE 2

STEAM PRESSURE GAGE	TOTAL TEMPERATURE	SUPERHEAT	VACUUM	STEAM FROM BOILER	POUNDS STEAM	PERCENT	BTU. FROM BOILER
lb. sq. in.	*°F.*	*°F.*		*Btu. lb.*	*BHP/hr.*		*percent*
250	505	99	28	1,264	9.6	100	100
400	675	227	29	1,347.5	7.3	76	83.3
400	750	302	29	1,389.5	6.9	72	81.2
600	750	261	29	1,379.5	6.85	71.5	80
600	850	361	29	1,437	6.5	67.8	79.2

The majority of water works plants today operate on steam pressures less than 250 pounds and temperatures lower than 500°F. (100°F. superheat). There are a few exceptions with steam pressures of about 300 pounds and superheats of 200°F. (about 620°F. total temperature). I shall, therefore, take a steam pressure of 250 pounds, superheat of about 100°F., and vacuum of 28 inches mercury as a basis to show what can be gained by adopting modern pressures and temperatures, including a vacuum of 29 inches, which can easily be obtained in most water works plants throughout the greater part of the year. As can be seen from table 2, considerable reductions in fuel cost can be realized.

The last column in table 2 shows the percentage reduction in Btu's

required from the boiler following the adoption of increased pressures and temperatures. As can be seen, an increase in pressure of only 150 pounds and in temperature of about 250°F. from the old basis of 250 pounds and 100°F. superheat, results in a reduction of almost 20 percent in heat taken from the boiler. This does not include the fuel savings which will be realized from the improved efficiency of modern steam generators as compared with older boiler plants.

In other words, because of the use of air heaters, economizers, more efficient boiler heat absorbing surface, better insulated furnaces, and improved combustion, a greater percentage of the heat originally contained in the coal is delivered in the form of steam than was formerly the case. In fact, where a 75 percent boiler efficiency was previously considered good, designers are now aiming at better than 90 percent. Accordingly, without taking into account the improved pump and steam turbine efficiencies possible today as compared with 20 years back, a water horsepower can now be produced with from 30 to 35 percent less fuel than is actually required in most existing water works plants today. A pumping plant operating 24 hours per day and 365 days a year is, it should be noted, an ideal location for a high economy boiler and turbine unit. The pressures and temperatures given in table 2 are not excessive nor do they result in materially increased cost over the old low pressure plant. Reliable operation is also assured, based upon several years' actual experience with such pressures and temperatures.

In conclusion, I should like to emphasize that in spite of the high degree of perfection in regard to both efficiencies and operation reached in the modern centrifugal pump and steam turbine, there are still channels open to reduce the operating costs, both in old plants and in new ones, be they electric or steam. In electric plants, the water works engineer should analyze his operating conditions carefully to determine if variable speed of the pump is warranted. This applies to old and new plants alike. In old steam plants the investment to replace or to supplement boilers and turbines with high pressure, high temperature equipment may pay very handsome returns. For new plants when the choice lies between electric power and steam turbine drive, it is very important to make the comparison on the basis of the entire operating range and further to select steam conditions according to modern central station practice.

DISCUSSION

G. H. LEAVERTON (Bureau of Water Supply, Baltimore, Md.): Mr. Peterson's paper on how to reduce the cost of operating centrifugal pumps, to many of us, including myself, was most interesting and productive of new ideas, particularly because it presents a new angle of operating conditions with which we here in Baltimore have had scant experience.

As you all doubtless know, Mr. Peterson is a widely known pump designer and engineer, and in his capacity of Chief Engineer of the Pump and Compressor Department with the De Laval Steam Turbine Company undoubtedly encounters many kinds of operating conditions in municipal, private and commercial fields to which we municipal engineers seldom have access.

You gentlemen, as members of the Four States Section, are primarily interested in pumping of a municipal nature. Therefore, it is permissible to exclude from our discussion of centrifugal pumping those operating conditions which are to be found principally in commercial enterprises and to confine ourselves to water works operation.

At this point, unfortunately, it becomes necessary for me to disagree with Mr. Peterson on him premise that "pressure variations in operating conditions" occur in most water works plants. However, I agree with him that these variations do occur in those plants of the direct pumpage type.

But in the majority of plants to be found within the confines of the Four States you gentlemen represent, I maintain that direct pumpage, being defined as "practically closed systems," does not obtain.

Throughout this section, in fact throughout the whole Eastern seaboard, an absolutely tight pumping system, whereby the fluctuations of draft cause radical pressure variations, is decidedly in the minority. The prevailing practice is to pump into a system having a standpipe, tank or reservoir floating on the line, which tends to stabilize pressures as well as furnish a reserve supply for non-pumping periods. These storages vary immensely in capacity, depending on their age, expansion of territory they serve, or because of insufficient or unavailable funds to construct ones of proper and adequate capacities. Nevertheless the practice is general and the trend is predominately towards more and larger storage mediums.

With this condition, the selection of efficient pumps resolves itself to one of sufficient capacity and practically one operating net head, which still may vary as much as 25 or 30 feet without seriously affecting the normal efficiency of the pumping unit. The most difficult problem for the water works engineer then is to select a unit or units of such capacity as will, considering his available storage of the particular system, supply the district at the present time and provide a surplus to take care of territorial growth.

In large cities, there usually are several separate and distinct service zones, determined by topographical conditions, each with its own balancing reservoir of tank, and these services are tied together but maintained separately by division valves. Furthermore, these service zones usually overlap so that the bordering territory may be shifted in an emergency from one to another.

BALTIMORE OPERATING PROCEDURE

Baltimore, in spite of being on tidewater, is decidedly hilly, necessitating the use of eight zones supplying service from zero elevation, or tidewater, to an elevation of approximately 700 feet. Each has a separate pumping station and storage unit. The larger stations are all equipped with three or more pumping units of various capacities and slightly varying net heads, said variance being necessary to compensate for higher friction losses as the capacity increases.

You gentlemen are not only interested in the planning of your pumping stations but in their operation and, as the subject under discussion is how to reduce pumping costs, a brief description of how we operate ours may be of value.

At our Vernon Station we have three units: 30, 40 and 50 million gallons daily nominal rating, supplying what is known as the Western Middle Service Zone balanced on a reservoir of approximately 190 million gallons capacity.

As Mr. Peterson stated in his paper, the design of centrifugal pumps has been brought to a high degree of efficiency, and he quoted the largest of these three pumps as having an over-all efficiency of 88 per cent. He further said or intimated that it was in active operation at this time, which was a natural conclusion, but I am forced to correct him, as it is not now in active operation nor do I expect it to be for quite some time. All of which brings us to the question of load factor.

Where electricity is used as the prime mover, the charges for high tension service consist of demand and consumption rates. It is unnecessary for me to discuss in detail these rates as you are all conversant with them, but suffice it to say that a demand, once established, continues for a period of time, originally one year with all power companies, recently reduced to monthly by some, the general trend being for all companies eventually to give the monthly revision privilege. We are speaking now of units larger than 200 k.w. and high tension or 13,000 volt service.

But to return to our cited operating method at Vernon Pumping Station. For approximately 5 months of the year, during the winter season, the consumption figures for the zone supplied by this station amount to approximately 28 million gallons daily. At first thought there appears to be little choice whether we pump this daily amount in 16, 20 or 24 hours. Now the smallest unit here is a 30 million gallon daily pump, driven by a 1000 horse power synchronous motor, which together with electricity used by auxiliaries, lighting, etc. produces an average demand of 830 k.w. This means a running period of about 22 hours per day or a load factor of 90 percent. The demand cost amounts to $1120.50 per month.

Now suppose we were to operate our next larger unit, namely the 40 million gallon daily, driven by a 1400 horse power motor. This would only require 16.8 hours pumping per day with a load factor of only 70 percent. The average demand amounts to 1160 k.w. or $1566.00 per month. The consumption costs we may forget, even though they would be slightly higher. From this we gather that by increasing the load factor 20 percent we actually save $445.50 each month. I shall leave it to you to compute how much it would mean to run the 50 million gallon daily unit Mr. Peterson mentioned with its demand of 1424 k.w.

As previously stated, this condition prevails for about five months each year, and about this time of the year the consumption begins to pick up. Then what an incentive we have when about the 25th of the month we find that our reservoir level is gradually dropping to hold off until the first of the month before putting the larger unit on the line. Sometimes we win out and at other times the consumption proves too great.

We frequently find that we can stave off the operation of a larger unit for a few days by shifting some of the boundary territory be-

tween two zones where one of these zones is in better condition than the other. This usually can be done at a slight cost by operating perhaps a dozen valves.

Our contract with the power company is also very liberal in that we can transfer a load from one station to another without affecting the established demand, provided we do not exceed the combined loads. This has proved very advantageous to us several times in an emergency.

The 40 million gallon daily unit will, we expect, provide sufficient capacity to take care of our needs for some time during both the winter and summer seasons. I might mention here that even though the biggest unit has about a 2 percent higher over-all efficiency it cannot begin to compete against the reduced demand charges.

Similar conditions prevail in all of our large stations, and in some we are further concerned during the peak summer months about increasing our electric demand more than 50 per cent because, although our power company is one that gives us monthly demand adjustments, should we exceed an established demand by more than 50 per cent it cannot be reduced more than $\frac{1}{3}$ in any one month, and the newly established figure obtains for a full year from its creation.

Mr. Peterson, in his paper, stated it was his desire to avoid partisanship in favor of steam or Diesel drive. We in Baltimore are not so modest; we frankly proclaim that we favor electric drive, believing it to be the better for our conditions here, where we have only pumping to consider.

Both Mr. Small, the Water Engineer, and I came into the Water Bureau when all stations were steam operated, and are not, therefore, entirely unfamiliar with the merits of steam as a prime mover. We have seen the passing of the old reciprocating horizontal pump, the vertical triple expansion type, as well as the later steam turbine driven centrifugals.

Where a municipality can operate a steam plant, and have other useful activities in connection therewith, such as heating, generating its own street lighting, etc. that constitutes another story, but that is far beyond the limits of this discussion.

Electricity is the only prime mover that lends itself to strictly automatic operation. Here in Baltimore we have at the present time three automatic stations, where no operators are on duty at any time, supervision being maintained by a telephonic supervisory system, created and perfected by Mr. Small, by means of which we

keep in touch three or four times daily with these stations. Personal contact is confined to weekly visits to change charts and attend to and oil the equipment.

Of course, should trouble develop a visit is called for. Our most frequent visits are caused by line surges outside of our control, which cause the safety devices to function and require manual resetting.

(Presented before the Four States Section meeting, April 24, 1936.)

METER SIZING

By Howard W. Niemeyer

(*Indianapolis Water Company, Indianapolis, Ind.*)

It is unfortunate that the loss of revenue due to meter oversizing cannot be exactly shown. If each water plant superintendent could have added to his monthly financial report a red figure showing his exact loss because of this improper practice, considerable discussion would result. We can, however, only indicate possible losses.

One of the prime purposes of meterization of the public water supply is to eliminate waste, not only from carelessness, but by leaky fixtures and plumbing. The meter must record all waste before it has cared for all of its duties. Even though the water meter of today is an accurate instrument, it has certain limitations. Let us look in table 1 at typical minimum registration and 100 percent accuracy flows for the various sizes of the disc type meter available on the market today.

Very few plumbing installations in the country are 100 percent tight. Continuous waste is occurring which ranges from the zero flow to the minimum registration point of the meter installed. Not until these leaks become sufficiently large to register on the meter is the customer aware of the condition or is the company paid for the water served. Allowing a value of 18 cents per hundred cubic feet, the possible monthly loss per meter will range from 18 to 72 cents for the $\frac{5}{8}$-inch meter, and from \$1.44 to \$6.12 for a 2-inch meter. It is therefore most important that the minimum sized meter be selected in order to hold down possible losses due to small leaks and waste. This importance increases as the plant operator lowers his standards for the make of meter purchased.

Current practices for meter sizing allow the meter to be either the full size of the service, or to be one size smaller. There are so many factors affecting a customer's service that this set rule is not practical. Main pressure, tap size, length of service, size of service, stop-and-waste valve, meter connections, bends, inside plumbing, unreamed pipe cuts, appliances such as automatic heaters and softeners, number and type of outlets, class of services which fixes the coinci-

dence of fixture demand—all have a bearing on the service and must be considered as a group in the selection of the meter size. The size of service alone does not determine the required rate of flow through the meter.

For the purpose of this discussion, let us consider domestic service only. Assume that the average dwelling sits 75 feet from the main, and has 40 pounds main pressure, then the maximum flow available with satisfactory pressure through a $\frac{3}{4}$-inch service is about 10.5 g.p.m., and 20.0 g.p.m. through a 1-inch service. From the standpoint of available flow, a modern $\frac{5}{8}$-inch meter with direct ports will meet requirements in both cases within its safe capacity and without excessive pressure loss. Furthermore, our experience has shown that the maximum demand for the average dwelling using tank toilets will

TABLE 1

METER SIZE	RANGE OF MINIMUM RATES OF FLOWS	
	For registration	For 100% accuracy
inch	*g.p.d.*	*g.p.d.*
$\frac{5}{8}$	25 to 100	100 to 750
$\frac{3}{4}$	40 to 175	375 to 1450
1	60 to 250	500 to 2200
$1\frac{1}{2}$	125 to 500	900 to 3600
2	200 to 850	1450 to 5750

range from 8 to 10 g.p.m., and the large single dwelling with several bathrooms and tank toilets will demand a maximum of 15 g.p.m. The use of a meter larger than $\frac{5}{8}$-inch in either case would be unnecessary and be only oversizing.

Most errors in meter sizing are probably made for multiple dwellings. My attention was first directed to this fact when a 2 by $\frac{5}{8}$-inch compounded meter was set in line with a 2-inch disc meter for a comparative accuracy test on a large apartment building. Of the total use over a period of one month 89 percent was recorded on the $\frac{5}{8}$-inch bypass meter, indicating very little flow over the change-over point which occurs at about a 12.0 g.p.m. rate. The under registration of the 2-inch disc meter was found to be 3.7 percent, or a value of $1.60 for the month. This loss would accumulate to $20.00 annually for this one service.

More recently we have completed several 24-hour demand studies

of several large apartment buildings. As an example, chart results for two of these studies follow:

	NUMBER OF APARTMENTS	TYPE TOILETS USED	FLOW IN G.P.M. IN 24 HOURS		
			Maximum	Minimum	Size meter used, inch
(a)	48	Tank	27.5	2.6	$1\frac{1}{2}$
(b)	45	Flush valve	65.0	1.8	2

The results of these checks show quite clearly that coincidence of demand is very low even though a large number of fixtures are served. They further show that, although the waste flow accumulated from all fixtures was sufficiently large to be within the registration limit of the size meter used, it was not within the 100 percent accuracy range. In the first case, only 27.5 percent of the meter's rated capacity was used; and in the second case, only 40.5 percent. I can see no reason why these meter sizes should not be reduced so that their rated capacity is more nearly utilized.

The plant operator should remember that the smallest meter used will not only hold low flow losses to a minimum, but will give minimum investment and maintenance costs when the meter is damaged by frost or hot water, or has to be opened for any other reason.

(Presented before Indiana Section meeting, April 7, 1936.)

THE RELATIVE IMPORTANCE OF THE METER DIVISION TO THE WATER DEPARTMENT

By La Verne Trentlage

(*Superintendent, Meter Department, Elgin, Ill.*)

Economically, these are days of tight money. Yet normal expenditures, even increased expenditures, continue to go on. These financial problems are not only felt by our administration, by manufacturing, wholesale, and retail systems, but right in our own water departments, whether they be privately or municipally owned.

In water systems the only means of meeting current financial needs is either by the process of taxation or the raising of prices, either one of which is a burden to Mr. Public. However, in the case of the water department, the problem of increasing the revenue does not, necessarily, have to be met by the method of increased water rates, which is a form of taxation or higher prices, but by the *increased efficiency of the meter division.*

The less business-minded water superintendent or governing body of that department might say, "We are satisfied our meters are running, though they were put in new twenty years ago; of course, when they stop we try to repair them. Our income is satisfactory, so we are content to coast along." This deplorably lax condition exists in a large majority of our water departments, both large and small. Every water department has a meter division, but in the above case, and many more, usually the only work done is to test a meter upon the consumer's demand, set a new meter for a new service, or repair a stopped meter after years of constant service.

After all, your water department with its various public service branches (pumping station, water mains, and meter division) really makes up a large chain. The old saying: "a chain is no stronger than its weakest link" applied to the water department becomes "no water department is stronger than its meter division." For the meter division is strictly on the "revenue-end" of the business. Of what value is the fact that you are able to pump enough water to meet every demand in time of record draught if you cannot tell in

the end, how much of that specified amount pumped you have sold, or, at least, accounted for in the cases of flushing the mains, sewers, business streets, and supplying water for fires, street sweepers, and other free services. Many superintendents forget the fact that each meter, whether large or small, is in reality a cash register.

As foreman of the meter division of a very successful water department as far as cents, dollars, and improvements are concerned, I have drawn the conclusion that the meter division is the "hub" of the water department.

Because three quarters of the water department is on the production end of the business, the superintendents usually lose sight of the revenue end, and because they do, they automatically forget the meter division, as the two go hand in hand. The day that you turn your eyes away from the activities of your meter shop you are starting on the downward road that surely leads to the "RED INK" side of the ledger, as far as water receipts are concerned.

If you keep your meters registering and testing correctly at all times your water receipts need not fall below the line of normal income as when they were first put in new, conditions being the same. Summarizing what I have said, "Your steady, needed income depends upon the efficiency of your meters, for only through them do you know how much you sell." Their efficiency, in turn, is dependent upon the efficiency of the personnel of the meter division.

CHANGES IN ELGIN

In Elgin our meter division, as well as the entire water department, was in such a run down condition when we took charge that nowhere in the entire system could the pulse be felt, nor could any sign of life or activity be seen. There are many men in the meter game who are either University graduates, or who have had three or four times the amount of experience I have had. When I stepped in to do some "extra" work one warm June morning I did not even recall ever seeing a water meter. The shop was located in the old City horse stalls, with the partitions removed. All the repair parts we had for twelve different types of meters could be found in two cigar boxes.

Whenever a meter was torn down the cleaning process that followed was like this: after thoroughly scraping and using steel wool on the measuring chamber, it was rinsed in cold water. (Don't ask how long it took.) The train gear simply had four or five shots of

penetrating oil to loosen the corrosion, and the meter was ready to be assembled and tested. If it registered on a stream equivalent to that used when you draw a glass of water from the faucet it was called O.K.

To make a long story short, I asked for the job of foreman when the opportunity presented itself. In six months time I attained that position in name only, for I lacked in actual experience. Today the results will prove that I caught the vision, saw a need; and with the help and splendid coöperation of each man, lifted the meter division out of its lethargy.

In the first place we converted the warehouse into a fine meter shop, 27 × 30 × 14 feet, with a nice little office facing on the south side. Our next step was to map out correctly the route for the meter readers to follow. Once over the entire city, consisting of three sections as office billings are made quarterly, we had our difficulties ironed out as far as routes were concerned. But we also learned a few startling facts. We found 1200 meters of many sizes were not registering. Some had not done so for ten years; the office was simply estimating the bill. Some houses never had a meter, and were getting water for nothing. On the other hand, some houses that were metered had not received a bill for as many as eleven years. It was evident that most of the meter reading had been done from the parks, popular club rooms, or from the curbing. The only way that one can tell about meters in service is by the information of the read card, e.g. stopped, leaking, frozen, damaged, or removed from service.

We use the loose card system. We found in time that no matter how careful we were, some cards would go astray, causing us to repeat a call, which caused questioning on the part of the consumer. We then installed a system whereby the readers record their readings or information on their official route books. Immediately the problem was solved.

Our next difficulty in this same field was the "pick ups." When the reader was unable to gain entrance at the initial call he went back on Saturday. If he again was unable to gain entrance he made the third call after 5:00 P.M. Sometimes it worked and sometimes it did not. Occasionally it would be six or nine months before we could get the actual reading. Under those conditions the bill would be smaller, for under our rates the more water you use the cheaper it gets. Of course, we were losers in several ways. In order to

combat that and save all of our chasing a red card was printed with several beneficial teeth inserted. As a result of that card, the readers make just two stops, the regular, and a Saturday call; then leave the card, if necessary.

Last, but not least, we were confronted with the nuisance of people allowing debris to cover the meter. There were too many cards coming in reading, "Meter covered; by furniture, wood, junk, or what have you." That condition led me to write forms like a personal letter requesting coöperation in keeping the meter in the clear at all times. Today our meter reading is a pleasure instead of a problem; it is absolutely thorough and punctual. Every meter is read every quarter, or the reason recorded in the ledger. One of our meter readers has had three years of University training, while the other, a High School graduate, is very accurate, one mistake per thousand reads.

To this point I have dealt with the meter division from a very general standpoint. In reality there is only one angle open for discussion—the subject of meters, for they are the backbone of the division. Regardless of size, type, or make, they are all originally a piece of mechanism designed to measure water. There are many makes and types of meters, yet in principle they are the same. After spending four years at the bench testing and repairing twelve makes of meters I should like to discuss some of the more technical aspects of the meter problem.

QUALITY OF METER

From the meter salesman's viewpoint he has the "best meter," but my experience teaches me that the majority of meters are far from being the "best." In principle, they are all the same, but they vary in: (1) workmanship; (2) materials; (3) machining; (4) length of time to repair.

The better meter rates high in these four qualities, but I am satisfied that excellence in these four qualities is not enough. The best meter has an additional fifth point. Because of this point it will not only maintain a higher range of accuracy on all flows, but its ability to register upon the abnormally low flow sets this meter in a class by itself. This is the fifth point to consider in judging a meter—"The ratio between the train gear and the amount of nutations in the disc chamber." Every meter had a ratio, but seemingly most of them have failed in their design to obtain the results in sensitivity

that this "best" meter has achieved. Some meters have larger or heavier parts than others, yet if they can perfect that ratio it need be no drawback on that meter.

CLEANING METERS

In Elgin we have water averaging from 20 to 33 grain hardness. It is composed largely of calcium bicarbonate with some iron. These minerals cause a deposit to form on the inside of meters. Meters in service for ten or more years we found very difficult to clean. Our first cleaning method was very crude. Under those conditions we could not expect to turn out as good a meter as a thoroughly cleaned one. It was a total failure in its purpose. Following that we employed the use of an acid. To our dismay it proved a failure as far as our hard water is concerned.

Today, through the process of time, travel, observation, and information obtained from platers, a meter company, and a large chemical company, we have a most efficient and thorough method of cleaning and bright-dipping brass and bronze meters. The formula when put into use is harmless and inexpensive. In order to use the process it is essential to have the proper equipment.

From our hot water heater and 30 gallon capacity tank we are able to fill both compartments of a laundry tub with either hot or cold water. Next to and parallel with the tub is a bench large enough for two 10 gallon crocks. To complete the ground floor equipment a gas plate has been installed. Over both crocks a large, funnel shaped hood is held in suspension by a vent pipe that connects to and continues on through the roof of the building. In the vent pipe, on the second floor, a ventilating fan capable of changing 1500 cubic feet of air per minute has been installed. The fan itself is inside while the motor is placed outside to escape the fumes. Because of the piercing, strong fumes this fan is a necessity. On the gas plate is a cylindrical shaped kettle three feet in depth, into which 10 gallons of water are poured; to the water are added 2½ pounds of tri-sodium phosphate. (The formula calls for 2½ pounds to 4 gallons.) When this solution has reached 200°F. the dismantled meter parts are immersed in it. Regardless of the amount of corrosion, the length of time for this treatment is only fifteen minutes, because of the hot solution. From our experience we have learned that tri-sodium phosphate will loosen anything but concrete.

The next move, with the aid of copper wires *only*, is to dip the parts

into clean hot water before lowering them into muriatic acid, 18°. There, the time limit varies from 30 seconds to 50 minutes, depending upon the meter part and the strength of the acid. For the sole purpose of reheating we dip back into the tri-sodium phosphate for just one minute, following up again with the hot water wash to neutralize the parts. Now the parts enter their final bath or the "bright-dip" solution, consisting of sulphuric and nitric acids, and a large handful of rock salt. Length of time of immersion is from 3 to 30 seconds depending upon the strength of the solution. Before the parts enter the "bright-dip" solution they are 100 percent clean but have a dull color. After coming out of this solution they are of a yellow gold finish. They are then swished through clear hot water. Hot water is preferable here because it enables parts to dry more rapidly.

The bright-dip process is not a real necessity. Whether you employ it or not has no effect upon the functioning of a meter. But its *psychological* effect upon the consumer is a valuable asset to one's department. For when a consumer sees his old meter replaced by a repaired one that looks no better than the meter being taken out, he feels that he is getting a meter in no better standing. On the other hand, if he sees you replace that old one with a meter with a clean bright luster, he naturally feels more satisfied. Then if he should receive a little higher bill he will in all probability feel that his old meter had seen better days and be satisfied that he has no complaint to make. In the final analysis it is the test that satisfies the meter man, but it is that outward appearance that either satisfies or dissatisfies the consumer.

METER TESTING

Our entire discussion of the meter division really simmers down to the meters themselves. From any angle you care to take it, nobody knows what the ability of a meter is until it has been tested. Many people think that a meter is "testing" correctly because it registers upon a small stream of water. However, this is not true. Financially it is certainly no credit to any water department to have meters in service for a period of 15 or 20 years, without ever testing, adjusting, or repairing them.

The answer to the question "How do you know when to test a meter?" cannot be made in a general or promiscuous manner. It is a technical problem that requires absolute knowledge of the chemi-

cal analysis of the water that flows through the meters. Due to the minerals in solution in water, a building up process occurs within a meter. That process is more rapid in some cities than in others; that is why no general ruling regarding "time to test" can be made. This last statement can be applied locally as well, especially if water is taken from wells which vary in depth. For water from varied depths is usually from a different stratum, causing a mixed water to enter the mains at various locations; provided that the water is not treated.

The lax department seldom tests.

Privately owned, as well as progressive municipalities test a ⅝-inch meter within a six or seven year period if it registers under 150,000 cubic feet. Should that size meter register that amount within a shorter period, it is then tested, adjusted, and repaired if necessary.

Elgin's Plan. We followed the plan of the privately owned plant until the chemical analysis was complete on water from our wells which vary in depth from 35 to 2,000 feet. The tests showed that the water varied chemically, especially in hardness. After a long experimental period of testing, we found it necessary to test some meters at 60,000 cubic feet, due to the heavy amount of iron in the water of some of the wells which naturally caused a more rapid and pronounced building up process.

The high grade meter in any district where the amount of hardness did not exceed 22 parts per million we could allow to register as high as 100,000 cubic feet before testing. Beyond that registration, they would not register on a ¼ gallon per minute flow.

I noticed the results of the tests made on ⅝-inch meters in one of our large cities bordering Lake Michigan. At the conclusion of a 250,000 cubic foot run the high grade type of meter tested up to the American Water Works specifications. After the meters were dismantled and all parts "miked," the test showed that the amount of wear was really unnoticeable. I mention this as a comparison with the problem in Elgin.

The chemical analysis of your water will tell you "when" to test. The "register" on the meter will tell you when that time has "arrived."

I wish to emphasize this point; the only time to set your register back to zero is during the replacing of entirely new parts. After a meter has had its first actual "service" test instead of turning back

your register to zero as some do, it should continue on for another 25,000 or 35,000 cubic feet for it will again be time to test.

The reading upon your meter tells two things: (a) how much water you have sold the consumer. (b) the probable condition of the meter.

"How should a meter be tested?" can best be answered by advocating the installation of proper testing equipment. That setup will consist of a testing bench, tank and scales, authorized by the American Water Works Specifications. For real accuracy and a necessary part of our equipment, we use the special large sweep hand type of "test register" for testing purposes. Our policy is to purchase equipment that will pay for itself.

Only high grade meters will meet these requirements.

RECORDS

In order to function properly, a meter division must have a good system of records. It is not necessary to delve into the higher forms of bookkeeping, nor do you need to hire an accountant, just a person who understands the business thoroughly. In the final analysis a method is desired that will record every move that is made on a meter from the day of its initial installation until it is junked from a particular address, or, in other words, you simply record the history that each meter is constantly making.

Practically every department uses the small file cards to show meter changes. In addition to that, we have the use of two special forms which we devised ourselves. The first form is filled out by the repair man. One half of that information is recorded in a large indexed book while three quarters of the information is translated and recorded on the second form, which is so arranged that at the end of each year from date of installation, the results in registration can be recorded and compared with the previous year. In that way we know just what the service is doing.

Important as it is to know that your meters are being kept in nearly perfect condition, to know the chemical analysis of the water so that you may know when to test your meters, to have the proper equipment for testing, it is equally important that you understand each individual service to the fullest extent. I refer particularly to sizes of 1-inch and larger. As there are no two designs alike on a frosted window glass in the winter, neither are any two services alike, for each one presents a problem all its own.

When your industrial services are 100 percent metered you have then laid the foundation for a work that will later prove to be of vital importance to the meter division. The problem of learning the true nature and G. P. M. demand of each service would be almost endless without the use of the recording register.

The facts that you will derive as a result of its application plus your knowledge of meters, flows, and loss of head charts will advise the correct size and design of meter to employ. By putting that knowledge into practice you are bound to increase your revenue. Prior to using the Recorder in Elgin we repaired all of our meters beginning with the 1-inch. In doing that the meters would be more sensitive and accurate. After charting several services we called the Recorder the X-Ray Machine for it gave us "the inside dope" on the service. In order that we might complete the job of service charting as quickly as possible we purchased two recorders which we keep active seven days a week.

The results we have received since using this apparatus have been most gratifying both to the consumer and producer of the water. Most of the results in the increase in revenue came in the field of reducing the 2- to 1-inch sized meters, and in the replacing of compounds by disc meters. In replacing a 4-inch compound with a 2-inch disc meter it picked up an additional 10,000 cubic feet per quarter.

In another service of interest, a very high registration was built up from very low but constant flows in G. P. M. As a result of changing the 2- to a 1-inch meter, an additional 20,000 cubic feet were gained. Resulting from a change not only in size but in design, a 2-inch disc meter on a 2-inch service line was replaced by a 3-inch current type. In this case the increase in revenue amounted to about $75.00 per quarter.

The recorder proved to be a popular apparatus to a great many of our consumers in more ways than one. In some factories where they had their own well supply the recorder plainly showed that the night man would rather turn a small valve and use city water. At the end of the first 24 hours charting in our largest factory the apparatus recorded nearly as much water used per hour in a two hour period after the closing hour of the plant as it did when all the 3200 employees were working. Upon seeing the chart the chief engineer immediately interviewed his entire force of maintenance men and the cause was soon remedied.

In the instance of one of our cleaning establishments, at the conclusion of the first charting we asked the manager if they used any water at night. He said, "We really have no occasion to use any as the place is locked up after 6 P.M." But when he saw just how much water had been recorded at night he summoned his man and two plumbers. As a result, each day's charting proved they were progressing in locating and fixing leaks. Finally no flow of water was registered at night while the day load was reduced by one-half. The manager made the statement that the charting of his service was "the smartest business move ever made in his plant in his behalf." We realize that in some instances we lose revenue, but we are ever mindful of the fact that we are here to "Serve the Public."

The recording register will erase all doubts concerning the nature of a service and the ability of a meter. It will answer questions which, although they may be of no direct interest to you as the head of the meter division, may arise in the minds of the consumer and of the producer of water. It is not necessarily true that because a consumer has a 1-inch service line he needs a 1-inch meter. Perhaps he only needs a $\frac{5}{8}$ or a $1\frac{1}{2}$-inch. Only the recorder knows.

(Presented before the Illinois Section meeting, April 10, 1936.)

Appendix

(1) Dip meter parts for 10 minutes in hot Trisodium Phosphate solution ($2\frac{1}{2}$ pounds or more of T.S.P. in 4 gallons of water).

(2) Remove meter parts from T.S.P. solution and rinse in hot water to remove alkali.

(3) Dip parts in Muriatic Acid 18° solution (1 part Muriatic Acid 18° to 2 parts of water). Allow meter parts to remain in Muriatic Acid bath for approximately 15 minutes or longer if necessary.

(4) Rinse parts in hot water and then immerse in the bright dip solution consisting of 1 part Nitric Acid 38°, 1 part Sulphuric Acid 66° and 1 part water, plus a handful of common salt. Leave the parts in the bright dip for 5 to 10 minutes, the length of time depending on the composition of the metal and the brightness desired.

(5) Rinse in boiling water to remove acid.

(6) Dip parts in stabilizing solution specially prepared for this purpose and allow to dry.

Caution

Always add acids to water when making dilutions so as to avoid spattering of the acid. Acids are corrosive to most materials including clothing and human flesh, so be careful to avoid splashing of the acid when dipping the meter parts. In case acid accidentally splashes on hands or face, wash same at once in clean water.

Do not use iron or steel wire for dipping meter parts. Copper or monel metal wire is satisfactory.

WATER SUPPLY FILTRATION AND SEWAGE TREATMENT IN CITIES BORDERING LAKE MICHIGAN

By R. T. Reilly

(*Assistant Engineer, Alvord, Burdick & Howson, Consulting Engineers, Chicago, Ill.*)

The development existing today in the territory bordering on Lake Michigan has taken place in the short span of a little more than 100 years. Other civilizations ripened and matured by centuries of experience still lack much in the way of wholesome water supplies and adequate facilities for treatment of sewage. Therefore, the admitted deficiencies in these regards throughout the area we are discussing become understandable.

Man always has been prone to give heed only to those matters pressing on his attention. This principle applies to individual problems as well as to problems affecting the general public. In the latter case, the ultimate solution usually occurs only after long and costly delays because the problem necessarily must impress its importance upon the public conscience in order to awaken a demand for its solution.

The demand for adequate treatment of water supplies and waste products is becoming insistent throughout the cities bordering Lake Michigan. The work that has been done recently in this field, notably that at Milwaukee where construction of a 200 million gallon per day filter plant is in progress, and the activity of the North Shore Sanitary District and of a number of lake shore cities in sanitary work, is a reflection of the increasing demand on the part of the general public for such facilities. There has been a period of apparent public indifference to this problem. It seems to me this indifference has been due to a lack of knowledge of the factors involved and how best to cope with them. Our own profession has been none too alert to its responsibilities in this regard.

The relationship between water supply and sewage treatment as regards cities bordering Lake Michigan is influenced by many factors, among which may be mentioned tributary populations, volume

of pollution, volume of receiving water, travel of pollution, turbidity, the efficiency of water supply and sewage treatment plants, and the ability of the tributary populations to meet the cost of such improvements.

Lake Michigan is a body of water approximately 320 miles long and 80 miles wide with a maximum depth of 850 feet near its northern end. The south end is relatively shallow. This portion of the lake receives an enormous volume of pollution. These relatively shallow depths is a factor influencing the intensity of pollution throughout this portion of the lake.

TRAVEL OF POLLUTION

The prevailing currents in Lake Michigan are related to the travel of pollution in these waters. This matter has been studied very thoroughly upon several occasions covering the Chicago water front, and further north along the lake at Racine and Milwaukee. The results of these studies indicate similar conditions wherever sewage contamination reaches the lake and variable winds and waves are available for dispersion. The results from these studies are well summed up by Maj. W. V. Judson in his paper on "Currents in Lake Michigan" (First Report Lake Michigan Water Commission, page 67):

"In my opinion the currents of Lake Michigan are so irregular in character that nothing would be gained worth the cost if attempt were made to obtain classified further data of a general nature. If it is a question of protecting the water supply of any particular locality, in any event, special study would have to be made inasmuch as the lake currents, available as they are, are much influenced by local conditions.

"We do know, and perhaps it is enough for the purposes of this commission, that occasional currents of considerable velocity, say several miles per hour, may be expected to arrive from almost any direction at any point reasonably near either shore of the lake. It is, therefore, apparent that in a general case if the waters of the lake are polluted by the discharge into it of large quantities of sewage, then, practical localities in the lake, even twenty or thirty miles distant from the point of entrance to the sewage, are not safe places in which to derive water for domestic use."

TURBIDITY

In drawing a continuous supply from the lake for water works purposes, it is necessary to locate the intake a sufficient distance from the shore to obtain the depth of water necessary to prevent ingress of sand and stoppages from anchor ice. A large supply

must necessarily be taken further from the shore and we find in Chicago that the intakes are located from two to four miles outward. The turbidity of the water drawn from a lake intake will vary between wide limits, depending upon the season of the year, the direction of the wind and consequent character of the lake currents. Upon the west shore of Lake Michigan there are long periods of summer season when the prevailing winds are from the west and south west. At such times the surface water is blown out into the lake and is replaced by return current along the lake bottom. During such times an exceptionally clear and pure water may be drawn from the intake.

Under the reverse conditions with easterly or northeasterly winds, the surface water is blown in toward the shore. Breakers are formed in the shallow water resulting in stirring up the dirty sand and accumulated sludge adjoining the shore and the water is returned lakeward as an undertow. At such times no clean or pure water can be obtained in depths at the intake under 50 feet.

At the Chicago intakes the turbidities range from approximately 5 to 100 with values considerably in excess of 5 over extended periods of time. In the consideration of turbidity it should be stated that a clean water such as is produced by water filtration plants has a turbidity of less than 5. Thus the experience at Chicago furnishes an index indicating the desirability of water filtration from that standpoint alone.

TRIBUTARY POPULATION AND POLLUTION

The lower portion of Lake Michigan and the principal cities bordering thereon are shown in figure 1. The size of these communities as governed by their respective populations is indicated by circles, the areas of the circles being proportioned to the population in each case. We thus have an index provided to indicate the relative volumes of pollution tributary to Lake Michigan at the different points shown. In the aggregate we have a total population of 5,000,000 people represented on figure 1. Excluding the Chicago Sanitary District, where the sewers have been diverted from the lake, there is a population in excess of 1,250,000 drawing upon Lake Michigan for water supply and depending upon it for disposal of waste matter. The volume of wastes poured into the lake amounts to approximately 100 tons of dry solids daily.

The communities bordering Lake Michigan in most instances lack

sufficient isolation from each other to insure protection from pollution originating in adjacent areas. This relationship is illustrated on figure 1. It is particularly true of the cities located along the

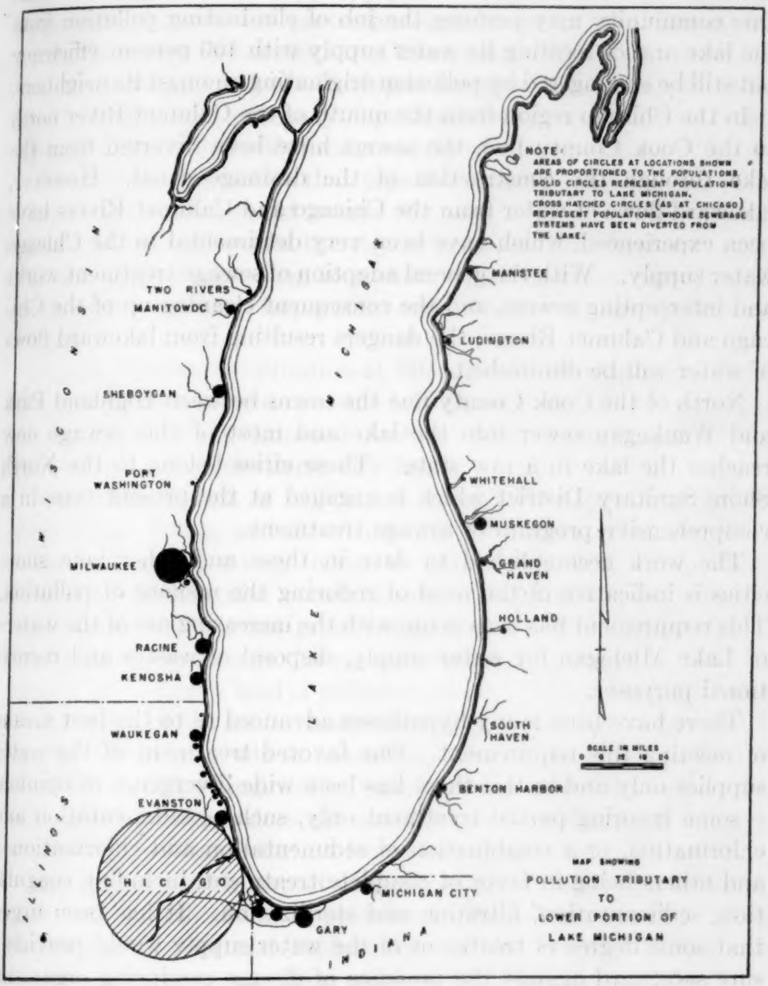

FIG. 1

southern and southwestern shore of the lake. This reach embraces the communities from Gary at the south to Waukegan on the north. All of these have boundaries in common. It is to be expected that

this situation will prevail in the not far distant future as far north as Milwaukee.

This close relationship indicates the interdependence of these communities in this matter of water supply and sewage treatment. One community may perform the job of eliminating pollution from the lake and of treating its water supply with 100 percent efficiency but still be endangered by pollution originating amongst its neighbors.

In the Chicago region from the mouth of the Calumet River north to the Cook County line, the sewers have been diverted from the lake through the construction of the drainage canal. However, lakeward flows of water from the Chicago and Calumet Rivers have been experienced, which have been very detrimental to the Chicago water supply. With the general adoption of sewage treatment works and intercepting sewers, and the consequent cleaning up of the Chicago and Calumet Rivers, the dangers resulting from lakeward flows of water will be diminished.

North of the Cook County line the towns between Highland Park and Waukegan sewer into the lake and most of this sewage now reaches the lake in a raw state. These cities belong to the North Shore Sanitary District which is engaged at the present time in a comprehensive program of sewage treatment.

The work accomplished to date in these and other lake shore cities is indicative of the need of reducing the menace of pollution. This requirement has been acute with the increasing use of the waters of Lake Michigan for water supply, disposal of wastes and recreational purposes.

There have been many hypotheses advanced as to the best means of meeting this requirement. One favored treatment of the water supplies only and in this there has been wide divergence of opinion,—some favoring partial treatment only, such as sedimentation and chlorination, or a combination of sedimentation and chlorination—and others being in favor of complete treatment, including coagulation, sedimentation, filtration and sterilization. It has been urged that some degree of treatment of the water supply would provide a sure safeguard against the presence of disease producing organisms in the drinking water supply. There have been advocates of long intake lines extending lakeward a sufficient distance to obtain clear pure water at all times.

Experience has brought out the weaknesses of these hypotheses. Sedimentation with chlorination was in use at Racine prior to the

installation of filtration. Other lake communities have tried this method of treatment, generally as a prelude to provisions for complete filtration. Practically all of the communities drawing upon Lake Michigan for water supply have depended in the past upon chlorination alone for protection against pollution. The notable examples in this connection are Chicago and Milwaukee. Chlorination as practiced on Lake Michigan has produced effective sterilization and at times extremely objectionable tastes. It is not a satisfactory method by itself of water supply treatment on Lake Michigan.

It has been urged also that provisions for the treatment or diversion of the wastes would restore the original purity of the lake and proper safeguards would thereby be provided for the water supply. Surprising as it may seem to us now, this hypothesis found support particularly in the important communities of Milwaukee and Chicago.

Figure 2 shows the situation at Milwaukee. Note that the sewage disposal plant is shown near the lake shore south of the Milwaukee River, and that the Linwood Avenue intake extends northeasterly into the lake near the north city limits.

The sewer system of Milwaukee is on the combined system and accordingly during periods of heavy flow by-passing of mixtures of storm water and sewage occur at points of outflow in the river. Heavy by-passing also occurs at the sewage treatment plant, the capacity of which is not great enough to provide treatment for the heavy flows reaching it during such times. Accordingly, there are times when a heavy load of pollution reaches Lake Michigan. Some protection against contaminations reaching the intakes is afforded by the breakwater which forms the outer harbor. Investigations made by the City Engineer's Department of Milwaukee shows that although this harbor does act more or less as a retarding reservoir, it does not prevent pollution from passing out into the lake.

The situation with respect to the southern end of Lake Michigan, where the concentration of pollution is the heaviest, was under investigation in 1924 and 1925 by the United States Public Health Service under the supervision of Messrs. H. R. Crohurst and M. V. Veldee.

This investigation was made in coöperation with the Sanitary District of Chicago, the Chicago City Department of Health, the Acting State Board of Health, and the Illinois State Department of Public Health. It focuses attention with emphasis on the pollution

of Lake Michigan by sanitary sewage and industrial wastes. Crohurst and Veldee conclude their report with the statement that the

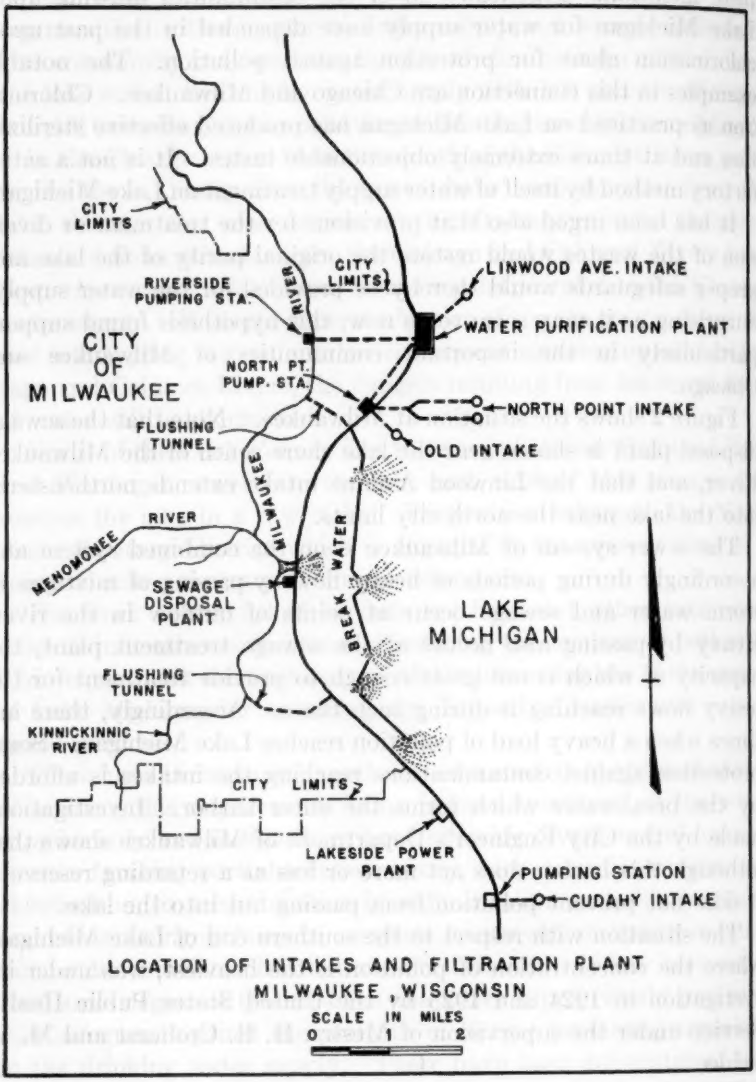

FIG. 2

obvious remedy for the present extremely unsatisfactory conditions at the southern end of Lake Michigan is abatement of the existing

pollution from sewage and industrial wastes reaching the lake directly or through the Calumet River and Indiana Harbor ship canal.

Figure 3 is a general map of the City of Racine showing the main drainage lines, the intercepting sewers built to date, the proposed

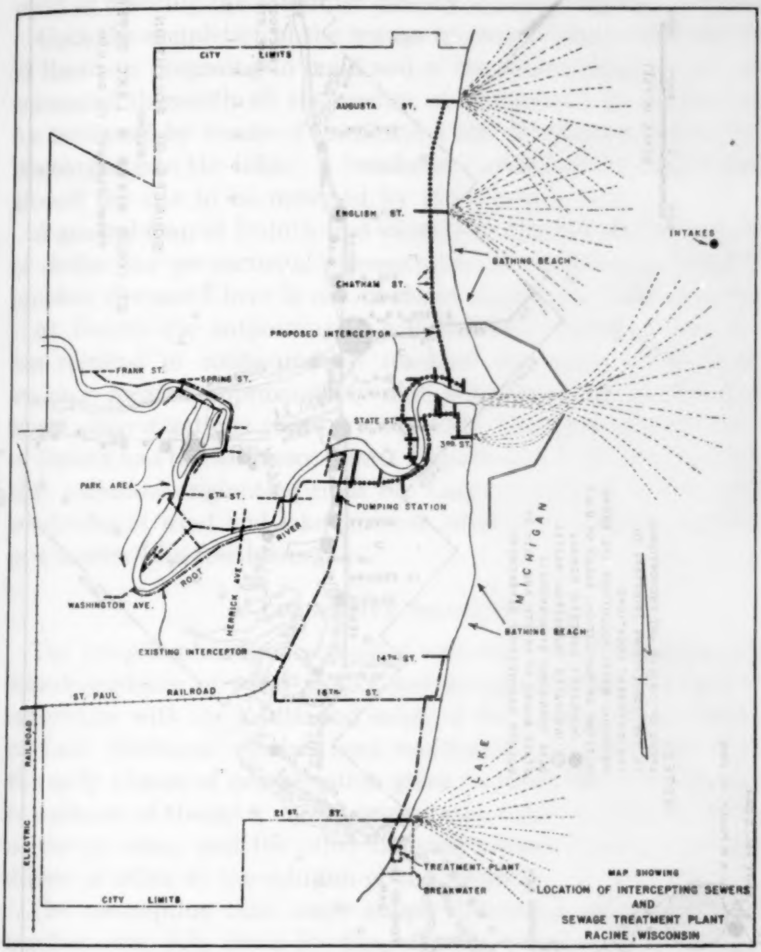

FIG. 3

intercepters, the location of the proposed sewage treatment plant, and the water works intake.

A photograph taken at one of Racine's main sewer outlets which discharges directly into the lake demonstrates the manner in which

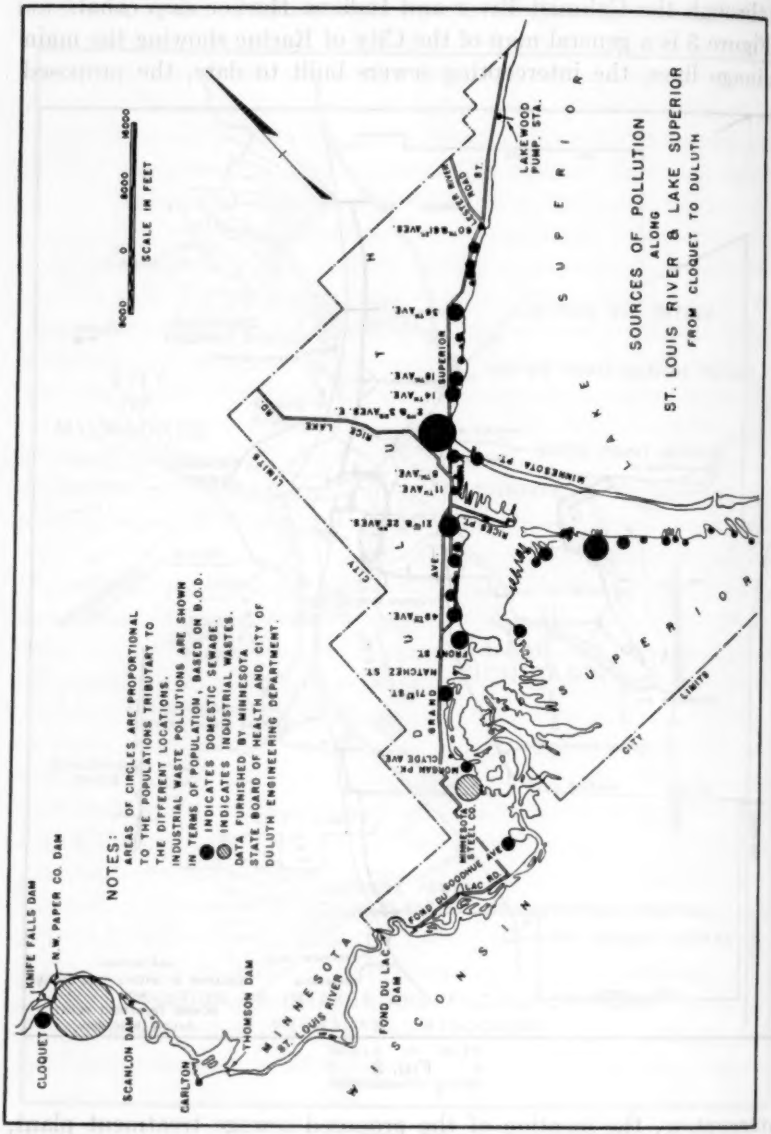
SOURCES OF POLLUTION
ALONG
ST. LOUIS RIVER & LAKE SUPERIOR
FROM CLOQUET TO DULUTH
NOTES:
AREAS OF CIRCLES ARE PROPORTIONAL
TO THE POPULATIONS TRIBUTARY TO
THE DIFFERENT LOCATIONS.
INDUSTRIAL WASTE POLLUTIONS ARE SHOWN
IN TERMS OF POPULATION, BASED ON B.O.D.
INDICATES DOMESTIC SEWAGE.
INDICATES INDUSTRIAL WASTES.
DATA FURNISHED BY MINNESOTA
STATE BOARD OF HEALTH AND CITY OF
DULUTH ENGINEERING DEPARTMENT.
SCALE IN FEET
CLOQUET
KNIFE FALLS DAM
N.W. PAPER CO. DAM
SCANLON DAM
CARLTON
THOMSON DAM
ST. LOUIS RIVER
FOND DU LAC DAM
MINNESOTA
WISCONSIN
LAKE SUPERIOR
LAKEWOOD PUMP. STA.
CITY LIMITS
SUPERIOR ST.
RICE LAKE RD.
MINNESOTA PT.
MINNESOTA STEEL CO.
MORGAN PK.
GRAND AVE.

FIG. 4

streams of pollution travel lakeward. The effect of such pollution travelling in this manner in contaminating the supply entering the intake located in this case 7000 feet from the sewer outlet is certain to be manifested in the character of the water reaching the treatment plant or reaching the consumer directly if such safeguard is lacking.

Upon the completion of the sewage treatment plant which the City of Racine is proposing to build and of the intercepting sewers to be connected therewith all the sewage of Racine will be concentrated for treatment by means of clarification and chlorination before being discharged into the lake. A breakwater completed in 1935 extends around the site to be occupied by this plant.

A general map of Duluth and vicinity in figure 4 shows by means of circles the proportional concentration of pollution and that the problem discussed here is not confined entirely to Lake Michigan. At Duluth the outpouring of pollution from the St. Louis River has resulted in contamination reaching the water works intake, which is located approximately nine miles from the mouth of the river. Investigations made by the City Engineering Department of Duluth and the Minnesota State Department of Health has shown that pollution originating from St. Louis River will under certain conditions of wind and lake currents reach the water works intake in a matter of a few hours.

CORRECTIVE MEASURES

The foregoing has been presented with the view of illustrating the interdependence of water supply and sewage treatment facilities in connection with the health and safety of the communities bordering on Lake Michigan. It has been mentioned previously that during the early phases of consideration given to these matters there were two schools of thought, one favoring water supply treatment in some degree or other, and the other favoring sewage treatment in some degree or other as the solution of the problem.

The assumption that water supply treatment only satisfies the requirements, falls down for the following reasons:

1. It is not practicable to extend water works intakes far enough into Lake Michigan to obtain an unpolluted supply of water because, first, it is not economical to do so, and second, there is no certainty of obtaining such a supply of water prevailing at all times and throughout all seasons of the year.

2. The concentration of pollution in certain sections of Lake Michigan notably at the present time in the southern end thereof, is such as to break down the efficiency of water treatment facilities of the most complete kind.
3. The water supply treatment facilities represent the last line of defense between the consumer and the disease-laden raw supply. Occasionally a weak link develops in the best of equipment or devices. It is important therefore that the raw water supply be made as safe as practicable. Sewage treatment facilities of the proper degree and properly operated will answer this requirement.

The assumption that sewage treatment alone will meet the situation collapses for the following reasons:

1. Most of the sewerage systems throughout the communities in question provide for the by-passing of the excess flows which occur during times of wet weather.
2. Sewage treatment plants as ordinarily designed do not provide capacity adequate for the treatment of the heavy flows which occur during wet weather even in instances where the sewerage systems tributary to the plants are designed and operated under separate plan.
3. Sewage treatment plants as ordinarily designed do not provide that degree of treatment adequate to safeguard water supply when the latter is withdrawn from a point near the discharge of the effluent from the sewage treatment plant.
4. There are sources of pollution, such as from passing boats, difficult and impracticable to control.

Therefore, even with sewage collecting and treatment facilities of the most comprehensive character, the opportunity remains for pollution to enter the water supply. The requirement calls for providing the best line of defense known to the art of water treatment, namely, that of filtration aided by those valuable auxiliaries of coagulation, aeration, and sterilization. Recognition of this has come about in the ranks of engineers and sanitarians concerned with the problem. There is now a general unanimity of opinion among engineers of the interdependence of water supply and sewage treatment facilities and the most practicable solution of this problem. The holdbacks are to be found in other ranks and principally among the mass of uniformed people. Occasionally an exception to this is found, as in one of the west shore communities, I encountered a doc-

tor who argued against any provisions being made for sewage treatment on the ground that the water filtration plant was adequate protection.

When such opposition is encountered, it of course makes the matter of winning the support of the general public somewhat more difficult. This has been well illustrated at Milwaukee where at one time there was considerable opposition to the construction by the city of a water treatment plant, the building of which is now in progress. City Engineer Joseph P. Schwada is to be congratulated for his energetic and persistent work in urging this extremely important and worth while matter upon his community.

Coming closer to home, we find somewhat the same situation in Chicago where there has been persistent and determined opposition to the inauguration of a water treatment program. This opposition finds much of its roots in that old belief that the removal of wastes from the lake as has been practiced by the Chicago Sanitary District for over thirty years, is all that is required to safeguard the water supply. The advocates of the opposing belief have fortunately been just as persistent and now it appears that the battle for improved water supply for Chicago is about to be won. Much credit is due to the engineers of the Chicago Water Department for the fine educational program that has been carried on in this connection.

CONCLUSION

The investment cost of water filtration varies between $6.00 and $20.00 per capita, and the cost of sewage treatment, exclusive of the connecting sewers, varies between $4.00 to $15.00 per capita, depending upon many factors including the size of the community, degree of treatment, and the conditions of construction prevailing in each case.

The question whether these represent figures which the average community can afford to expend for such facilities is not to the point. Rather they represent in a general way the price we must pay for existence. It is becoming obvious, as evidenced by the newspaper accounts of the recent epidemic at Milwaukee, that we can no longer afford the cost of continued neglect of this problem.

(Presented before the Illinois Section meeting, April 10, 1936.)

THE EARTHQUAKES OF 1935 AND THE HELENA, MONTANA, WATER SYSTEM

By J. E. Lupien

(*Foreman, Water Department, Helena, Mont.*)

About 1:00 A.M. on the morning of October 12, 1935, Helena experienced a major earthquake, the first since the summer of 1925. While the tremor lasted less than seven seconds, it did considerable damage to property, especially to chimneys.

Investigation of the reservoirs and pipe lines revealed no damage. All service pipes are owned and maintained by the property owner. It was then decided to check some of the larger ones. They were all found in good condition, except for one 4-inch cast iron line serving the County Hospital. This line is 6000 feet long with about 1000 feet laid in a swamp. In this section twelve loose joints were found. This line is not anchored in any way to keep it from shifting. The joints are precaulked with lead.

Another major shock lasting forty seconds came at 9:45 P.M. on October 18, 1935. Two men were killed by falling debris and a number of people were injured. Brick and masonry structures suffered, some with side walls, others with front and back walls falling out. Still others were down completely. Some cracked up so badly that they had to be torn down. Fortunately the weather was moderate, or there might have been fires to contend with. The city was in darkness for almost two hours, all power being off owing to fallen wires.

DESCRIPTION OF WATER SYSTEM

A brief description of the city water system will assist the reader in a better understanding of the results caused by these quakes. There are four main sources which furnish water to the Helena system. The high pressures for the business district come from the Ten Mile Creek Drainage area. After first being treated with chlorine and ammonia the water flows into a reinforced concrete settling basin built in 1931 with a storage capacity of 6,000,000 gallons. This is wholly a gravity supply, with waters stored in Chessman Reservoir

and distributed in part through the Woolston Reservoir on Mount Helena. The original Woolston Reservoir was built in 1888. It is formed by excavation and embankment, the bottom being lined with concrete which extends to the 4-foot concrete core wall in the center of the embankment. The inside slopes are covered with 8 inches of broken stone and paved with hand laid rip rap 12 to 15 inches thick. The reservoir is approximately rectangular in shape, and has a storage capacity of 2,126,208 gallons. In addition, a second Woolston Reservoir was established in 1931, a reinforced concrete structure with a storage capacity of 3,000,000 gallons. The Woolston well and pump station, located north of the city, is an auxiliary supply which is sometimes used to augment this Ten Mile supply.

The West Main Street Bedrock and the Eureka systems are unique in that they both collect waters which flow at a depth of about 40 feet on bedrock. These waters originally supplied placer workings, being later acquired for public uses. Both originally were distributed by gravity and the upper, or West Main Street Bedrock, still is. From 1930 until January 6, 1936, the Eureka waters were pumped from a deep sump and discharged to the upper part of the Ten Mile distribution. On the latter date, a change in the pumps was made to discharge these waters to the Hale Reservoir, built in 1887. It is excavated in solid rock, the bottom being lined with concrete and the side walls with masonry 24 inches thick, with a masonry wall 9 feet high and 20 inches thick all the way around. This reservoir has a storage capacity of 2,165,908 gallons. This is a gravity system furnishing water to the south and east part of town. There were two sources of water feeding into the Hale distributing reservoir. These were both subsurface drains and springs, one in Dry Gulch and the other in Oro-Fino Gulch.

DAMAGE

The water works system as a whole suffered a loss, but also enjoyed some gain. There was but one leak in the distribution system, a ¾-inch corporation stop being sheared off at the main. The sources of supply and the flow lines did not fare so well. At the Woolston pump station about half of the smoke stack fell. This was built in 1887, was about 125 feet high, of solid brick laid with very hard and rigid mortar. It had an inner lining of brick. The pump house, a solid brick structure, cracked badly. Feeling certain that, if there were another major shock, the building would go down, ten men were

put to work immediately building a structure out of 8- by 6-inch timbers and 3-inch plank to protect the pump so that it could be operated, if necessary. This structure was completed in eight hours. It is 18 feet long, 15 feet wide, and 10 feet high. Although the Eureka water was muddy for about ten hours, it was found that the flow of water in the well had increased from 350 to 750 gallons per minute.

Fortunately the Hale Reservoir got its supply from subsurface drains and springs in two gulches, Dry Gulch and Oro-Fino Gulch. It was found that the Dry Gulch supply had gone absolutely dry, while in Oro-Fino Gulch there was an increase of about a million gallons per day. A new spring was also discovered coming out of the mountain side at a point not over one hundred and fifty feet from our pipe line. This spring formerly flowed but in recent years had been dry. It now has a flow of 36,000 gallons per day and can be developed to produce more.

Investigation of the 8-inch vitrified tile flow line from Oro-Fino Gulch to the Hale Reservoir showed about 15,000 feet cracked so badly that it will have to be replaced. The County Hospital pipe line showed thirty more loose joints in the swamp. These were tightened by driving the lead back into the joint.

Minor shocks were recorded off and on from October 18 until noon, October 31. Then the third major shock came lasting twenty seconds. Two more men were killed, several hurt, and more buildings fell. The temperature had dropped to five degrees below zero with a light snow-fall, making it miserable for people without homes. A crew of eight men were busy turning off services, due to the vacating of homes, and within 24 hours two hundred had been turned off. There are 3,300 altogether in the city.

The Woolston pump house fell down in a heap. Our foresight was proven correct and the structure built over the pump after the October 18 quake stood the blow and the pump was saved. The wiring had to be changed, but the pump was ready for use whenever needed. In other respects, everything remained the same as it was after the shock of the 18th.

The Eureka supply still has its 750 gallons per minute, the Oro-Fino Gulch its gain of a million gallons per day, the new spring the same amount of water, and Dry Gulch is still dry, with no signs of ever getting wet again. While this supply never did deliver more than perhaps 25 gallons per minute, it did service about thirty houses

from a 4-inch gravity flow line before going into the reservoir. These houses are higher than the reservoir, which means that now it is necessary to pump the water to them at a cost of twenty dollars per month.

Special interest is attached to the casings of the two wells, the Bedrock and the Eureka. Both are easily accessible for inspection. The Bedrock well is lined with a 36-inch tile laid dry. An inspection made on January 13, 1936, showed no trace of dislodgement or breaking of this tile. The Eureka well is lined with reinforced concrete, being 6 feet square. No evidence of damage had been found in this structure, although a pump attendant reported being violently thrown about while in the well at the time of the major quake on October 31.

An interesting observation was made when repairing the tile flow line feeding the Hale Reservoir. Many lengths were found to be cracked identically, two lines showing from about the middle of the spigot end and running back and diverging, reaching to the bell about two-thirds of the way around on either side.

The chlorinators on the Helena systems, with the exception of that on the Hale, are housed in small solid brick structures with wood roofs. The Hale supply chlorinator house is dug fifteen feet into a steep hillside. The walls are of solid brick lined with hollow tile. The roof is of reinforced concrete, covered lightly with earth. Not one of these houses, nor any of the equipment, suffered damage from the tremors. There was no interruption in the treatment of the water. Especial attention was given this feature by both the Water Department employees and the State Board of Health.

It will cost the Water Department about thirty thousand dollars to replace the damage done by these earthquakes. In addition to this there has been a loss of $2,578.70 revenue from October 18, 1935 to March 31, 1936. This is not so bad, perhaps, when one considers that the area has experienced three major shocks and 1811 lighter shocks in the five and a half months from October 12, 1935, to April 2, 1936.

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RAILROAD WATER SUPPLY PROBLEMS IN MONTANA

By E. M. Grime

(*Engineer of Water Service, Northern Pacific Railway Company, St. Paul, Minn.*)

It takes the fastest passenger trains operating in transcontinental service 18 to 22 hours to cross the great State of Montana. The distance varies from 681 to 767 miles, depending on the route. In traversing this distance a good many things may happen to delay one of these trains, and of the numerous services required to function 100 per cent efficiently at all times, an adequate and satisfactory water supply is by no means the least.

The water required for a passenger locomotive traveling over this distance will be about 75,000 gallons. That for a freight locomotive two or three times as much. Multiply this by the number of locomotives in service, add the water consumption demanded for the various services at terminal points to keep the locomotives in proper condition for regular operation, and we arrive at 12,000,000 gallons as the approximate daily railway water requirement in this state. On the Northern Pacific, water consumption in Montana averages 3,900,000 gallons per day and of this amount 54 percent is purchased from those municipalities where the supply is adequate, satisfactory, and available at reasonable cost. It is the general policy of the railroads to purchase their water from the local communities, but as they are usually compelled to make large investments in such facilities, as pipe lines, storage tanks, water columns, and frequently water-softening plants, and furthermore must maintain their own water department organization, they cannot afford to purchase such water at anything greatly in excess of what it would cost to provide their own supply. Twenty-nine percent of the water used on the Northern Pacific in Montana is softened for locomotive boiler use.

Montana has a population of about 538,000 and an area in square miles almost the same as that of Japan. Montana is said to have more tillable acres than Japan which supports a population in excess of 56,000,000. In crossing this sparsely settled domain, most of

which has been populated since the coming of the railroads, it was found necessary to establish terminals at many isolated places where no habitation existed, and a survey for an adequate water supply was one of the first considerations.

IMPROVED REQUIREMENTS

The Northern Pacific, traversing the valleys of the Yellowstone and other rivers for a good part of the distance across the State, was fortunate in finding adequate supplies in many places from these streams, and elsewhere the supply was obtained from the smaller mountain streams, deep wells, or municipalities. Some of the small streams flowing off the granite slopes of snow-capped mountains still retain their virgin purity, but others have become so contaminated due to settlement of the surrounding country that they are unfit for use in locomotive boilers or stationary plant boilers until purified by some kind of treatment. This is particularly true of the Yellowstone river which the Northern Pacific, main line and branches, follows for 450 miles. Thirty years ago this stream was considered an ideal locomotive supply after its water had been put through a simple settling process to remove the mud. About the time this method of treatment had been perfected, the boilers began to show signs of corrosion. From a small beginning this trouble increased until in the worst districts boiler tubes and flues, instead of lasting the limit of four years permitted by the Federal law, and then being safe-ended and replaced for another four-year period, had to be removed and scrapped after 12 to 18 months' service. Since a set of locomotive tubes and flues costs in the neighborhood of $2500.00 and replacement puts the locomotive out of service for a month or more, this soon became a serious situation. Investigation showed that the quality of the water in the Yellowstone River, which is clear and pure at its source in the Park, became progressively contaminated in the distance from Livingston to Glendive. This was traced very largely to pollution caused by the discharge of irrigation waste water at various places along the stream. This was particularly noticeable after the opening up of the Huntley Irrigation Project about the year 1911.

POLLUTION BY IRRIGATION WATERS

When the soil is irrigated, it seems that salts, principally sodium sulphate, as well as the sulphates of calcium and magnesium, are

drawn to the surface and then washed off into the rivers. A shallow well close to the shore line of a stream where seepage from the river might be anticipated, will often show very poor water as compared to the river water a few feet distant. Tests for a seepage intake well on the gravel bar in the Yellowstone River, near Custer, showed 183 grains per gallon soluble salts, of which 36 percent was sodium sulphate. This was in a test hole near the edge of the irrigated ground. At a point 140 feet out toward the river channel, the total salts were 46, and close to the edge of the stream a test showed only 21 grains. High water stages had evidently leached out the salts from the soil near the river. In the vicinity of Laurel, water samples taken close to the shore line of the river will show a salt content, mostly alkali, of 23 to 33 grains per gallon when the main stream has a total soluble salt content less than 7 grains per gallon. Black or brown alkaline seepage water can be observed coming through the gravel formation at the shore line even during the winter season when the irrigation ditches are dry. Occasionally when this type of water is drawn into the railroad zeolite softening plant, the capacity will be suddenly reduced as much as 33 percent and the salt demand for regeneration of the mineral increased by as much as two tons per day. The high sodium sulphate causes partial regeneration of the zeolite mineral, reversing the ordinary process and rapidly cutting down the capacity. Complete softening of all of the water in the district between Wibaux and Laurel, either by the lime soda or the zeolite process, and the constant maintenance of a sodium caustic alkalinity has extended the life of tubes and flues, from 12 to 18 months as previously mentioned, to 15 years or more.

Conditions similar to these, which exists along other rivers, and the poor quality of water from surface or deep wells in many localities have made the subject of boiler water treatment a major problem to railways in Montana as well as in sections of the neighboring states of North Dakota and Washington. Modern operating conditions demand ever increasing speed, not only for passenger power but also for freight, and the corresponding power increase makes greater boiler pressure desirable. All this adds measurably to the necessity for more refinement in the quality of the water used for evaporating purposes. Under present conditions railroads could not operate with the quality of water which was available 25 years ago, and long engine runs extending 900 miles or more in some cases, could not be made successfully.

BOILER WATER CONDITIONING

The science of boiler water conditioning has made rapid strides in the past 15 years and while there are yet problems not completely solved, there are few water supplies which cannot be very much improved by one of the various methods now available. The original lime-soda type still remains as the economical method for almost complete removal of temporary and permanent hardness. Refinements are often included, such as the use of sodium aluminate for a maximum reduction of hardness, especially under cold weather conditions, and where considerable magnesium is present. Also the use of a small quantity of tannin for prevention of incrustation in feed water heaters and injectors is often desirable. In other cases maximum reduction in hardness is accomplished by agitation and filtration through a bed of sand. Such filters are usually the pressure type and designed to float on the treated water discharge line. A small amount of alum hydrate is added to the water as it goes to the filter. This combines with the caustic produced by the lime-soda process to form sodium aluminate and this in turn picks up the unstable calcium remaining in the treated water and forms insoluble calcium aluminate which in turn accumulates on the top of the filter sand, creating the "schmutzdecke" necessary for efficient operation.

$$6\,NaOH + 6\,Al(OH)_3 = 3\,Na_2Al_2O_4 + 12\,H_2O$$
$$Na_2Al_2O_4 + CaCO_3 = CaAl_2O_4 + Na_2CO_3$$

The intermittent use of the locomotive, the fact that most treated waters, either in their natural state or by reason of treatment, are saturated with oxygen, and also the high content of sodium, calcium and magnesium sulphates in Montana waters, create corrosive tendencies. The most practical method so far developed to combat such corrosion is the continual carrying in the softened water of a sodium hydrate causticity equal to at least one-tenth of the sum of the sodium sulphate and sodium chloride salts. In actual operation a few evaporations of such water soon raise the causticity to the point where it inhibits the most prevalent corrosive tendencies. With a good many Montana waters this causticity is simply a by-product of the excess weight of chemicals required to carry the reactions to the point where the hardness is reduced to the desired one or two grains per gallon.

The next available method of complete softening and one which has come into use during the past ten years is the zeolite process. By the

use of either natural or synthetic zeolites, usually confined in a closed tank, the plant may be conveniently arranged to float on the line between the raw water pump and the soft water storage supply. The hardness ingredients, consisting of calcium and magnesium carbonates and sulphates, are removed by this base exchange method, leaving a sodium bicarbonate water of practically zero hardness. Treatment by this method for waters of high sulphate hardness usually costs less for chemicals than does the soda-ash method. The plan is also advantageous at locations where sludge from a lime-soda plant would be difficult to dispose of. One of its chief drawbacks, especially where the supply is taken from a stream, is the requirement that the water be almost clear and practically free from iron before it enters the zeolite bed. Since the zeolite acts by contact on the surface or within the pores of the mineral grains, it is necessary that there be no coating or plugging with foreign matter. Zeolite treated water or natural sodium bicarbonate water, such as that from the deep wells at Miles City, readily combines with lime-soda treated water and causes no difficulty in locomotive operation. Sodium bicarbonate waters elsewhere in Montana can be used as the source of soda for combination with lime for the purpose of softening hard water. Several plants using this combination are in operation in Western North Dakota and others are contemplated.

There are some localities where the natural waters are not sufficiently objectionable to justify the construction of complete softening plants. For these districts, comparatively inexpensive wayside treaters can be employed. In some cases sufficient soda-ash to neutralize the sulphate hardness is applied and in others sodium aluminate with an after-treatment of tannin is used. Such plants can be arranged to be almost automatic in operation, the chemicals being added in proportion to the rate of raw-water flow to the storage tank. With this arrangement the locomotive boiler in effect becomes a treating plant and it is necessary for the engineman to follow a consistent and almost continuous blowdown schedule to maintain the boiler water in a satisfactory working condition.

Another problem, not exactly technical, but always demanding solution, is that of deciding if the softening of a water supply can be economically justified. Some of the savings accomplished by water softening are rather difficult to capitalize, but it was early realized that if the scale accumulation could be kept at a minimum, there would be a fuel saving and also that the boiler repair work would be

materially reduced and locomotives kept in more continuous service. The Water Service Committee of the American Railway Engineering Association in 1914 came to the conclusion that the damage resulting from the accumulation of one pound of scale in a boiler amounted to seven cents. Since that time, due to the increased cost of everything entering into the calculation, that figure has been raised to 13 cents and the savings are usually calculated on that basis. That this is a conservative figure has been actually demonstrated in practice on various railways and it is not unusual to show savings of 25 percent per annum on the cost where a complete water treatment program has been inaugurated.

We have on the railroads, in addition to furnishing satisfactory water for locomotives, most of the hydraulic problems that usually are involved in a municipal supply system. Sometimes we have the problem of furnishing water of sanitary quality, and occasionally sewage and sludge disposal become a problem for the railway engineer. Lime-soda water as treated to a high caustic content is invariably found to be free from harmful disease germs. Such water has in the past been considered unfit for human consumption, but there are some communities in the East where it is the only drinking water available, and there are a few cases on record where this kind of water has apparently been found to be the cure for diabetes. We do not expect to encroach on the medical field and as yet we have no confirmation of this from medical authorities. We have noted with interest that one city in Montana has gone to the softening of its drinking water by the lime-soda method, obtaining from a soft water well the necessary soda, and such practice will probably increase as the advantages of softened water become more apparent. Railroad men believe that the public appreciates softened water and at several stations on the Northern Pacific we have put in zeolite softening plants, largely for the special purpose of providing suitable wash water on Pullman and other passenger cars.

This brief survey has covered a few of the numerous water problems which have confronted the railroads of Montana during the past 25 years. While considerable progress has been made, our work is by no means complete and to those who may be interested in a field for intensive research I suggest study of the following problems:

Corrosion of boiler metal—its complete annihilation.

Foaming of boiler water—its cause and complete control.

Embrittlement of boiler metal—if due to water conditions, how can it be avoided?

DISCUSSION

B. W. DeGeer, (Engineer of Water Service, Great Northern Railway Company, St. Paul, Minn.): Mr. Grime has mentioned that corrosion of boiler metal, foaming of boiler water, and embrittlement of boiler metal all merit further study. No doubt a number of those present who are in charge of city water supplies have had complaints from steam boiler operators because of one or more of these troubles. Corrosion is probably the most serious, as very few boilers operated on raw water are entirely free from either pitting, grooving at flue ends or general rusting of a fairly uniform nature. Many hypotheses have been advanced as to the cause or causes of corrosion but one which can be fairly well substantiated by experimental data is somewhat as follows:

In the absence of oxygen, water reacts with iron at ordinary or elevated temperatures to produce hydrogen and a coating of black magnetic iron oxide on the iron surface and this action proceeds at room temperature until a pH of about 9.6 is reached. If oxygen is present, this black iron oxide is almost instantly converted to red iron rust, so pH 9.6, which is the hydrogen iron concentration of a saturated solution of magnetic iron oxide, is never reached by natural increase of OH ions due to release of hydrogen from the water and corrosion continues indefinitely. The same is true in the absence of oxygen if a large volume of gas free water continually flows over the metal, as in an economizer, for in this case the hydrogen formed, also the iron oxide, may be carried away in solution to such an extent that a rapid rate of corrosion is maintained. Corrosion may also proceed in the absence of oxygen if some substance such as carbon dioxide, clay, some types of boiler scale, etc., permanently buffers the solution below pH 9.6, and serious attack to the outside of iron pipe lines laid deep in the ground may possibly be accounted for in this manner.

Oxygen is present, however, in the vast majority of cases where corrosion is experienced and is by far the most prevalent of all substances which will buffer a solution of iron and water at some point below pH 9.6, and thus allow corrosion to continue. Carbon dioxide is probably the next most prevalent agent of this nature and it reacts with water to form a weak acid, which so far as it is able has the same buffering effect as any other acid.

Another unfortunate feature about corrosion is that it usually starts at the point which is subjected to the greatest stress and the more severe the stress the more rapidly does the metal deteriorate.

One example of this is when the long flues are placed in a horizontal boiler natural sagging occurs near the center and this places a point near flue sheets under heavy stress. If water conditions are such that corrison is possible, it is almost certain to start near the flue sheets, in a thin line running around the flue parallel to the sheet. As the metal eats away and the flue becomes thinner at this point, boiler pressure tends to place the thin spot under greater stress than the adjacent metal, and this additional stress tends to accelerate the rate of corrosion and hasten failure. No doubt much of the so-called grooving of flues is due to this feature.

Pitting may be due to small amounts of segregated impurities at certain spots in the metal allowing a slight "eating away" to start, which slightly weakens the flue at this spot. We then have various forces acting that are favorable to corrosion and failure. One is that the corrosion products are of different electric potential than the body of the flue, and as most boiler waters contain electrolites, galvanic action is set up and we have a little battery at this point, and as you know, one plate of battery always wastes away. As the pit becomes deeper, stress acts to increase the rate of corrosion and to hasten failure, as previously mentioned.

There would be little need of studying corrosion if no remedies were to be suggested, and fortunately, they have been offered by the hundreds. Some have been fairly successful and some the opposite, but the ones that seem most practical remove oxygen from the boiler water, and raise the pH to a point where little or no corrosion can exist. Sodium sulphite and tannin compounds are usually recommended to act on the oxygen, and necessary increase in pH can be accomplished with a mixture of caustic and carbonate of soda, or with soda ash alone if the boiler pressure is above 100 pounds per square inch, as soda ash reacts with water under pressure to form caustic soda and carbon dioxide. The extent of this conversion is dependent upon the pressure and some other features, but usually is somewhere around 80 percent under ordinary operating conditions. There are some limiting factors that must be observed in applying these remedies, as unless the proper amount of sodium sulphate is present in boiler water, or some other inhibitor, caustic soda is said to be the cause of embrittlement cracks, as mentioned by Mr. Grime.

A great deal of conflicting data has been published on this subject, and it is still being given very extensive study. Some cracks that a short time ago would have been declared due to caustic embrittlement

without hesitation because of their intercrystalline structure, are now known to be due to other causes, and authorities no longer seem so certain about their classification. We do know, however, that when boiler metal is stressed beyond the yield point either by poor workmanship, or by natural causes, cracks that follow between the metal crystals can be produced by strong caustic solutions containing a little silica, and that a sufficient amount of sodium sulphate, along with various other substances, prevent them from developing.

Up to a very short time ago it was not known that silica was required in the caustic solution to bring about these failures, and because of this fact few experimentors were able to check results obtained by others working on this subject. Much is being learned about embrittlement of boiler metal each year, but until more data are available, it seems advisable to maintain the recommended amount of sodium sulphate in boiler water to insure, so far as is possible, against embrittlement cracks.

Foaming of boiler water is described as a condition where the entire steam space becomes filled with foam or froth, part of which is carried out of the boiler with the steam. It is usually more serious in locomotive practice than in stationary boilers, but it may become very troublesome in any boiler that is not properly operated. In fairly pure water steam bubbles break near the water surface and cause no trouble, but as the boiler water becomes contaminated with various dissolved and suspended solids, both organic and inorganic in nature, bubble films seem to be given enough strength to persist for sufficient time to fill the steam space and cause wet steam. Two remedies are recommended to improve this condition. One is to remove sufficient water from the boiler through the blow-off cocks to prevent a foaming concentration from being reached. If this proves to be too expensive or is impractical for other some reason, an anti-foam compound containing about 15 percent castor oil can be used. This will permit very much higher boiler water concentration to be carried without serious carry-over.

(Presented before the Montana Section meeting, April 17, 1936.)

THE EDUCATIONAL SITUATION IN WATER WORKS ENGINEERING

By Harold E. Babbitt

(Professor of Sanitary Engineering, University of Illinois, Urbana, Ill.)

Possibilities of employment are in the minds of most young men when considering the choice of a career. The practical application of knowledge imparted is in the minds of most educators in professional schools. The crass materialism of these conditions is an object of severe condemnation by critics of our civilization. Viewers-with-alarm point to them as signals warning of coming disaster. Nevertheless they are *conditions* and they are *facts*. They can be avoided neither by viewing-with-alarm nor by condemnation. If truly dangerous, a road to avoid them may best be found through study resulting in knowledge rather than through neglect resulting in ignorance.

To be out of step, to be either ahead or behind the times is to be eccentric, impotent, ineffectual. To be of value, therefore, any discussion of the education of a water works engineer should be in tune with the times. If this be materialism then our studies must be made with the eyes of the materialist, with due consideration for such other points of view, or schools of thought, as may later affect the conditions to be met by the water works practitioner.

CHOICE OF A CAREER

The title of this paper intimates that there is something about the education of a water works engineer which differentiates him from other professional engineers. Beyond a certain point in every field of human endeavor there is a degree of specialization which differentiates the activities in that particular corner of the field from those in other corners of the same or contiguous fields. It is not the intention to intimate or to contend that the attainment of the highest knowledge in the field of water works engineering divests the individual of all abilities in other fields. On the contrary training in water works engineering develops breadth of knowledge and

versatility of ability. The route to be chosen in any career must be studied continually in mapping the plan of life. The first decision does not determine the ultimate destination. No freedom is allowed in choosing between illiteracy and elementary knowledge; that is determined by law. Beyond the elementary schools however, a choice must be made at every turn. After high school, what? If high school is selected what choice is to be made there; business or college preparatory? At the university the choices include agriculture, commerce, education, engineering, etc. In the engineering college one is confronted with electrical, mechanical, mining, civil, and a host of other branches of the profession. In civil engineering we find highway, structural, drainage, sanitary and other specialities to be chosen between. It is with the field of the last that the water works man is most interested.

INCENTIVES AND ATTRACTIONS

Let us study the mind and the motives of the student who has reached the point of choosing between the divisions in the field of civil engineering. Upon what bases must his choice depend? The chosen field must assure a living; economic security is desirable; there must be some chance to attain riches and power; romance and adventure should be possible; the career must be interesting, honorable and respectable; and to some the possibilities of service to others is an attraction. The requirements have been stated in the relative order of their merit in the mind of the chooser. First and foremost a living, the possibility of existing, must be assured. We may have riches without respectability; adventure without honor; service without romance; but none without a living.

THE ESSENTIAL INCENTIVE LACKING

Does a career in water works engineering promise an opportunity for service? Yes. Honor, respectability, interest? Yes. Romance, adventure? Yes. Riches and power? There are possibilities. Based upon the competence and education of the individual does the choice of this career assure a living? *NO.* Not today under our present system of recruiting engineers to the water works profession. In that negative answer lies the crux of an important difficulty with water works education today.

A career in water works engineering presents all but one of the features necessary to attract a student to obtain the best possible

education in the field. The one missing feature is the essential feature; the assurance of a living in the event the career has been chosen. This missing assurance is in the hands of the water works profession. It is not under the control of the educator. A young man may have all the attributes of personality, character and education desirable in a water works engineer and yet be unsuccessful in obtaining a position in the field even though positions are available.

FIELD NOT OVERCROWDED

Opportunities for water works engineers lie with public and private water works organizations, with industry, with railroads, with equipment manufacturers, in teaching, in private consulting practice, with federal, state, and municipal health organizations, etc. etc. The exact number of positions open to water works engineers is difficult to estimate but the membership of the American Water Works Association may give us a clue thereto, however inadequate this clue may be. The most recent membership list at hand shows about 2,400 members in the Association. Although not all of these are water works engineers there are probably more water works engineers out of than in the Association so that it would not be unfair to consider that there are probably more than 2,500 water works engineering jobs in the United States.

Members of the American Water Works Association are mortal and, being mortal, they die. Mortality tables for the United States show that about 15 to 20 persons in every thousand die annually. Applying this mortality rate to the American Water Works Association there should be approximately 35 to 40 recruits needed annually to fill the places made by death.

Let us now turn to statistics of the educational factories which are developing men specially trained in the field of water works engineering. In a study of the courses in sanitary engineering, in which the subject of water works is an important specialty, made by the United States Public Health Service (Public Health Reports, August 15, 1924, page 1989) it is pointed out that during the ten years preceding the publication of the report the average number of first degrees earned in sanitary engineering annually in all of the educational institutions in the United States was between 35 and 36. This should be good news for the sanitary engineers, who are specially qualified for a career in water works. Even if there were no other opportunities for them than in water works these statistics would indicate that

the supply does not begin to approach the most conservative estimates for the normal demand for recruits to the profession. Sanitary engineers are, however, in demand in other fields than water supply engineering and to assume that one hundred per cent are employed in the water works field would be erroneous. It would seem, therefore, to be a safe and conservative conclusion that preparation for a career in the field of water works engineering would assure a living to the student completing the requirements of a course specializing in this subject.

Experience does not fit the conclusion. Year after year a mere handful of students trained in water works engineering has been graduated from some institutions only to be unable to find employment in their chosen field. The "depression," with consequent shrinkage of employment in all fields may be offered as an explanation of the situation, but the depression has not stayed the hand of death which automatically demands the replenishment of the supply of workers in the field. Added thought reveals the depression as not an explanation of the continued unemployment of water works engineering graduates. More engineers of various types have found employment in water works during this period than have been graduated in the past decade. The truth of these facts is emphasized by the situation this year. The customary loyal and interested little handful of finely trained, capable young men is about to be graduated or will be available with first, second and even third degrees in the field, yet to my knowledge *not one* has received an offer of employment by a water works executive or personnel officer. They will go to other branches of sanitary engineering with resultant loss to the water works profession.

IMPORTANCE OF GOOD RECRUITS

Both members of the water works profession and engineering educators should be interested in such a deplorable situation which reveals not only a loss to the profession but a waste and disappointment of human effort and a waste of the public tax money. If the educator is at fault for training men who are unfit for the profession the profession should use its influence to ameliorate the situation. If the profession is at fault for not employing the best trained recruits available it should increase its efforts to ameliorate the situation. This Association should show active interest and concern to see that the education of its recruits is conducted in accordance with

its needs and to see that the members of the profession make use of such recruits.

If cast iron pipe is to be purchased, if cement is to be used on a job, if chemicals are to be supplied for the water purification plant, the water works man goes to the source of supplies to secure the best product which the factory can develop and he employs competent technicians to investigate the quality of the material. Private industry follows the same procedure but it goes the water works man one better. It proceeds to the source of supplies of trained personnel and investigates the product in its finishing stages at the factory. Personnel representatives visit the various educational institutions and interview prospective graduates, opening positions to the most desirable. As a result it obtains the cream of the product and offers the highest inducements to young men to strive for these positions. The water works profession is not being recruited in this manner. The best of the well trained recruits are not available to it because the water works profession is permitting the acumen and initiative of private industry to outsmart it.

OPPORTUNITIES FOR THE AMERICAN WATER WORKS ASSOCIATION

Fortunately for the hope of bettering the situation the water works profession is not too badly ridden by politics. Although primarily a governmental enterprise it is recognized as a self-supporting type of public service which can be conducted best by means of competent personnel, in which employment and advancement can best be assured by personal merit rather than through political affiliation. A part, and a large part, of the responsibility rests, therefore, clearly upon the water works profession which is able to make amends but is not now taking any active interest in the situation.

The constitution of our national organization states, in Article II:

> "The object of this Association shall be the advancement of knowledge of the design, construction, operation . . . of water works . . ."

An opportunity is offered, is open, for the more complete fulfillment of this "object" through the improvement of the education of recruits to the profession. We have committees on such matters as publications, membership, constitution, prizes, conventions, practice, licensing, and technical matters but none on education. Unquestionably here is a virgin field for increased activity, usefulness, and recruiting of the profession and possibly of the Association.

Other professional organizations show great interest in the education of their recruits. The various "founder" engineering societies have affiliated in the work of the Engineering Council for Professional Development, one of whose principal activities is the examination of the education of engineers for the principal branches of the profession. Most of these Societies foster student chapters which serve as centers for the cultivation of recruits to the profession and members in the Societies. The educators themselves have organized the Society for the Promotion of Engineering Education to maintain a high plane of education for the engineering profession. The influence of the control of the American Medical Association, the Bar Association, the Beaux Arts contests, etc. upon medical, legal, architectural and other professional education is well known. The American Water Works Association might do well to follow the lead of these older professional organizations.

Inactivity on the part of this Association in the field of the education of its specialized recruits may serve as an implied compliment to the educators in the field; leaving them to believe that all is satisfactory and that the Association is content with their accomplishments. Unfortunately it is probable that they do not so believe and, again unfortunately, the inactivity is not to the best interests of the advancement of knowledge to which the Association is dedicated.

SPREADING PROPAGANDA

It was recently my pleasant duty to deliver my annual lecture to engineering freshmen on the subject of the choice of a career in engineering. Such vocational lectures are given to our engineering freshmen by representatives of the various major divisions of engineering. These are frankly propaganda lectures in which each lecturer presents to his audience facts (and possibly occasionally some fancies) concerning the attractions in the field of his particular activity. To deliver a lecture on the attractions of the field of water works should not be difficult if one wishes to build on the prerequisites of a profession as outlined earlier in this paper. In the search for facts concerning the possibilities of a career in water works engineering, as a major division of sanitary engineering, rich and interesting material is available. Selection of material from this rich field is more difficult than its discovery. Interest, romance, adventure, service, all are to be found in abundance. But when it comes to security and employment silence is more effective than the

truth if young men are to be enticed to enter this field of specialization. Specialization in water works engineering lacks that most important prerequisite to attractiveness; the assurance of a job to the competent.

Such unattractiveness is neither desirable for the good of the men now in the field nor for the good of men who intend to enter the field. Even restricted professions, such as the medical, the public accountants, and certain trades influence the character and quality of their recruits. Our profession is not overcrowded with competent personnel but our lack of interest, shall it be called supineness, displayed by our failure to employ specially trained personnel discourages the capable recruit from training to enter the field. A result is a burden upon the educator to maintain a high standard in the education and training of the few brave recruits who hazard the loss of their efforts by entering the field.

MORALS IN EDUCATION

Since the title of this article might have led to the belief that it is devoted to the details of the subject matter taught in the education of a water works engineer some attention should be devoted to this phase of the subject.

Education is defined, in the words of the dictionary, as the systematic training of the *moral* and *intellectual* faculties. The word MORAL is all too frequently overlooked in the consideration of technical education. Fortunately for the future it would seem that more and more attention is being given to *morals*, even though we all may not agree on just what is or is not moral. The dictionary gives little light on the matter for it says: "Moral; conformed to right; that which is right according to truth, justice, or law." Since expensive disputes occur upon what is the law, there would seem to be little hope of general agreement upon truth and justice? Even the legal profession might be willing to agree that what is law may not always represent personal standards of truth, justice or ethics.

In spite of the handicap of the conflict between certain legal precepts and personal standards of right and wrong the legal profession is at least ahead of the engineering profession in that it teaches a code of morals. Morals for the engineer, whether he be of the water works persuasion or other clay, are learned at his mother's knee, in the parochial school, or hap hazardly. If he learns them in the development of his intellectual faculties through a technical educa-

tion the learning is fortuitous, not planned. Unfortunately, such a fortuitous education in morals may be distorted, erroneous, or even dangerous. That the situation is recognized is evidenced by the public statements of Dr. A. C. Willard, President of our State University, himself a well-known engineer, who has stated recently in his public utterances that one of the principal duties of the University is to train for citizenship and service as well as for a vocation.

Agreement upon physical laws and mathematical principles can be reached without great difficulty, but not so with respect to moral and ethical precepts. The teaching of principles upon which there is marked disagreement is difficult to organize, administer, and control. Misinformation as to the difference between moral right and wrong is potentially more dangerous than misinformation concerning the principles of structural design.

In the famous "Mann Report" on the investigation of engineering education conducted some years ago by the Carnegie Foundation, the qualifications of an engineer were analyzed and displayed in such a manner as to show 90 percent of his education to be character building and 10 percent to represent technical training. Regardless of the correctness of the figures the weight placed upon the value of character is impressive. Under our present form of education the technical school devotes little time or attention to character building. Dependence for such a qualification is placed upon extra-curricular activities, be they church, social, sports, business or other type. It is assumed that the student arrives at college with his character built or that it grows with him, like his hair.

The engineering educator pours the information into the vessel which is presented to him. If the vessel leaks, is cracked, is too small, or lacks other requisites for holding or returning the information it is no concern of the purveyor of technical information.

SUBJECTS OF STUDY

Now that one of the grossest faults of present-day policy in engineering education has been admitted let us turn hastily away from the horrible admission and consider some of its virtuous accomplishments. Water works engineering is recognized as among the principle activities of civil engineering, with a combination of some of the practical applications of mechanical and electrical engineering, mixed with the humanities. As a civil engineer the water works engineer must have a knowledge of those technical fundamentals common to

all engineers, such as: mathematics, engineering drawing, physics, mechanics, and elementary hydraulics. The education of the civil engineer begins to depart from that of other major divisions of the engineering profession in the study of structures, structural analysis, and structural design; surveying; earthwork; roads; etc. The water works engineer must be equipped with these fundamentals and differentiate himself from the other specialized branches of civil engineering when he studies such subjects as advanced hydraulics, water chemistry, water works materials and equipment, thermodynamics, electrical machinery, etc.

In order to show more clearly and in detail just what should be included in the building of the education of a well-educated water works engineer capable, so far as his education is concerned, of attaining leadership in his profession, the following table has been prepared:

The Structure of the Character and Education of a Water Works Engineer

Foundation: Personal integrity; character and development of the moral intelligence; appreciation of personal and civic responsibilities and obligations.

Ground floor: Ability to speak and to write good English; culture; appreciation of the good, the beautiful, and the fine.

First story: Fundamental technical knowledge common to all engineers including mathematics, physics, chemistry, drawing, elementary hydraulics, economics, mathematics of finances, the humanities such as sociology, philosophy, and psychology.

Second story: Basic knowledge for the civil engineer such as surveying, engineering mechanics, materials, methods of construction, excavation, foundations, tunneling, buildings, and structures and more structures.

Third story: Specialized knowledge leading towards water works applications; advanced hydraulics; the law as applied to practice, particularly in the field of contractural relations; thermodynamics; mechanism; electrical machinery and equipment; municipal government.

Fourth story: Knowledge requisite in the procurement of water: hydrology; meterology; demand; sources; structures for the collection of water such as intakes, wells, and reservoirs; sources of power and of pumping, equipment, and auxiliaries; pumping stations; materials, pipes, and fittings; aqueducts, bridges, and tunnels; distribution systems.

Fifth story: Special knowledge requisite in the determination of the quality and purification of water: sanitary bacteriology; chemistry; sanitary water analysis including bacteriological, physical, microscopical and mineral; methods of purification; design of purification plants; planktology; sources and prevention of pollution.

Sixth story: Special knowledge required in the maintenance and operation of the physical plant of a water works: location and stoppage of leaks; thawing

frozen pipe; installation and care of meters; care of dams, intakes, aqueducts, and the multifarious other structures and equipment which go to make up a complete water works.

Seventh story: The maintenance and operation of water purification plants.

The tower: Public relations; maintenance of good will; water works accounting; methods of billing; methods of financing, both public and private; valuation; administration.

ADDITIONS AND SUBTRACTIONS

Some of those who have listened attentively to the reading of the list have missed the presence of one or possibly more subjects held to be of special value and would recommend its or their inclusion in the curriculum. Before new work can be required in any curriculum of study it is necessary to make room for it by removing some subject now being offered.

Education is one of the few commodities sold today with which purchasers are satisfied with less than the amount paid for. Any attempt to increase the delivered amount of the commodity is received with resentment. Purchasers of knowledge are attracted to competing educational curricula which offer equal or better rewards with less mental effort. In arranging a curriculum in any subject the viewpoint of the student must be considered. The amount of effort required for the completion of the course must bear some balanced relation to the reward offered for its completion or the course will find itself without students. Our specialized courses in sanitary engineering, including water supply engineering, are approaching this condition; excellent courses but few students. In many educational institutions the cost per student of a sanitary engineering education is disproportionately high. What did it cost the State of Illinois last year to turn out the one sanitary engineer trained in water works engineering; what will this year's graduates represent in cost to the taxpayers? Has the water works profession displayed its appreciation of the time, effort, and expense spent by the State in the preparation of these men? It has not, for none has found employment in the field of water works engineering. Other professions are clamoring and petitioning for the installation of courses for the training of their recruits. This Association, the leader of the water works profession, should take cognizance of the situation and protect the advantages which fortuitous circumstances have thrust upon it for many years, but which might possibly be lost through inattention and lack of cultivation.

THE STUDENTS' VIEWPOINT

Educationally the special course in water works engineering is difficult to administer because of the breadth of the field which is necessarily covered. The student is most content when he feels that a valuable nugget of information has been acquired which can be placed in his memory for future use. Items of information on widely divergent subjects are not easily retained in the memory. It is difficult to jump from hydrology to ground water, from materials of construction to advanced hydraulics, from public relations to the specifications for filter sand. To hold the attention of the class and to maintain its interest during the period in which the course is offered it is necessary to offer sugar coating to make the ingestion of the information easier and more pleasant. It is not felt that this situation is so serious as to require drastic steps for its avoidance. The same conditions are met in other subjects. In each of the subjects of this type it is encumbent upon the instructor to make his course interesting and entertaining, as well as intellectually valuable.

Another deterrent to perfection of education in water works engineering is the lack of encouragement to students and instructors to pursue and to provide the education necessary for perfection in the field. The lack of incentive is due to the lack of a promise of employment upon completion of the requirements for an academic degree. Of the large number of engineers now practicing in water works engineering but few have specialized in the study of the subject during their undergraduate years. This is evident because there are more engineers active in water works practice than have have been trained for this service in the history of all of the educational institutions of the country combined.

In conclusion, I wish to emphasize the opportunity which is open to this Association to interest itself in the education of its recruits; the fact that it should be taking an interest in the problem; and the fact that the situation is of sufficient importance to merit the Association's serious attention to fulfill the obligations of its constitutional objective.

(Presented before the Illinois Section meeting, April 10, 1936.)

A YEAR'S OPERATING EXPERIENCE AT THE GLENDIVE WATER SOFTENING PLANT

By C. W. Eyer

(*City Engineer and Water Superintendent, Glendive, Mont.*)

Soft water, like any other public improvement, is now taken by the water consumer as a welcome addition to the general benefit and forgotten. I say forgotten in the sense that it has now become accepted and expected to be continued as just another improvement due and demanded by the consumer. The only criticism now heard is that the water is not soft enough. Our original intention was to produce a water of about 5 grains of hardness. This we have been able to do fairly successfully. However, in the spring of the year, when the river water is not so hard, we have produced a water with a hardness as low as 1.5 grains. Needless to say, the change is noticeable and desired by the user, hence the demand for softer water. Just another point to show that we humans are never quite satisfied.

In the actual operation of the plant, we have encountered some interesting problems. Our main difficulty has been in being unable, at times, to produce a water of low hardness and balanced to calcium carbonate. A balanced water is necessary to prevent:

(1) Corrosion due to undersaturation to calcium carbonate.
(2) Deposition due to supersaturation to calcium carbonate.
(3) Excess of lime in the fully treated water.

In the winter time, when the hardness in the river water is high and composed of considerable magnesium, it has been necessary to carry an excess of lime across the flocculator and clarifier as high as 6 grains in order to precipitate all the magnesium and hold the hardness down. This necessitates considerably more CO_2 than we are able to generate with the plant we have, and leaves an excess of lime in the fully treated water of about one grain. A high excess of lime is also necessary when the so-called red mud from the Big Horn River is encountered. Regardless of the amount of this red mud in the river water, it is exceedingly difficult to remove, but with large amounts, say anything over 10,000 p.p.m., it is a veritable nightmare. The last

time we had this red mud to deal with, the turbidity was over 30,000 p.p.m., the water fairly hard thereby throwing down a large bulk of flocculated material caused by the softening reactions, yet this red material refused to be collected by the floc formation and settle out. A high excess of lime helped some, but it still remains a major problem. It acts just as though the floc formed repels the red particles rather than attracts them. I sometimes wonder whether this is not the cause; that is, both the floc formed and the red clay carrying the same charge of electricity, thus repelling each other.

Some of the benefits found aside from the soft water produced are:

1. Increased filter runs. The average filter run is now in excess of 50 hours or about double what it used to be.

2. Reduction of bacterial load on the filters. Under the old system, our filters were heavily overburdened. Now, due to the excess lime treatment, the bacterial load on the filters is negligible and the fully treated water is almost sterile.

3. The aid of the softening floc in the removal of turbidity. Poor chemical mixing, under the old system, was not conducive to good floc formation. The large bulk of softening floc is a great aid in the removal of all turbidity. We now have little trouble in turbidity removal except for the red mud as stated above, and when exceedingly high turbidities are encountered.

4. The removal of objectionable tastes. During the spring run-off, bad tastes develop, most of which are removed by the excess lime treatment. Chlorine dosage has been reduced, removing the possibility of chlorinous tastes.

5. Continuous sludge removal. Complete plant shut-downs are now an exception rather than a monthly practice.

In going over our records, I have compiled some data as to the increase in cost of plant operation due to the softening process.

		cents per thousand gallons
Increase in power costs		0.82
Chemical costs		
Lime	2.25	
Aluminate	0.57	
Alum	0.05	2.87
Cost of CO_2 generation (Natural Gas)		0.10
Total		3.79
Less alum cost under the old system		0.29
Net increase due to softening		3.50

or an increase of approximately 30 percent in the actual plant operation. While this increase in the cost of production is considerable, our financial status is such that we have been able to absorb it without any increased cost to the consumer.

Some parts of the plant are not satisfactory in every respect, but taken as a whole, we are more than satisfied with the results produced.

(Presented before the Montana Section meeting, April 17, 1936.)

CORRECTION OF FAULTY PLUMBING

By H. D. McAfee

It is difficult to think of faulty plumbing and its effect on our drinking water supply without associating with it cross connections, but I shall try to limit this discussion to the subject assigned me. It has often proved the case that the man in charge of water purification has done his job well and produced a perfectly safe water at the plant only to have all his efforts nullified by faulty plumbing in the distribution system. Unless some one in authority sees to it that all faulty plumbing is eliminated or corrected, the public having full confidence in the water supply operator, may be surprised to find that they are using a water which is badly contaminated by sewage or some water from an unprotected source. This responsibility falls to the plumbing inspector and it is his duty to refuse to allow the installation of any plumbing fixture that may become a cross connection between a safe water supply and one that is unsafe. Furthermore he should inspect all old plumbing with the purpose of eliminating all health dangers caused by improper plumbing installations.

Any plumbing fixture in which water is fouled is a part of the waste disposal system and in many of these installations, especially the old ones, the opening of the water delivery line is below the water discharge opening leading to the sewer. In such cases it is possible to siphon foul water into the distribution system by cutting off of the water supply, breaks in the water mains, or, in the case of tall buildings, the opening of large valves at their base so that the pressure in the upper stories becomes negative. In this way contamination may be sent to all parts of the distribution system. Examples of this type of installation are, the old bath tub of the Bell Type and water toilets of not too recent installation. For the bath tubs, the only remedy is to discard them and install modern ones. Even when the opening is above the overflow, but below the rim of the fixture, siphonage may occur; water may be drawn faster than the overflow can remove it or the drain pipe may become clogged so that the polluted water can reach the faucet. Examples of this type are bath tubs of a very few years ago and found in countless homes,

lavatories, and sinks all with spouts below the rim. Obviously the remedy for such faults is to replace this plumbing with fixtures whose water discharge openings are high enough that the polluted water cannot reach them. Those water toilets, with their water delivery opening submerged by the badly contaminated water in the bowl, are also a constant menace to public health unless they are equipped with air breakers.

Some plumbing faults, and of no little consequence, are found where we would least expect them, namely in hospitals. Those water toilets used to flush bed pans are a real health menace if the flushing jet is submerged in the water contained in the bowl or in position to be submerged when the bowl is flushed or stoppage occurs in the waste line. I know of no correction for such installations beyond the questionable safety afforded by check valves in the water line which would minimize (but not eliminate) the danger of polluted water being drawn into the line. Instrument sterilizers and other fixtures with inlets at the bottom are potential dangers to the water supply. The placing of unsterile instruments in such a sterilizer and the opening of the water line when there is a partial vacuum in the line might draw infected water into the delivery system. The correction for such faults is to change the inlet to a point where it cannot be submerged in the contaminated water.

Some of the most obvious plumbing faults can be traced, not to ignorance on the part of the plumber, but to gross neglect. For example, the direct connection to the sewer of the waste line from an ice box or refrigerator in which foods are stored. Such a connection allows gases to be drawn from the sewer into the box when the door is opened. Also bugs and vermin are permitted to crawl into the refrigerator and over the food, carrying with them filth from the sewer. Those ice boxes in the basements of buildings thus connected could easily be flooded by sewage in case of stoppage of the sewer. Plumbing ordinances in many cities provide that the refrigerator shall discharge into an open water supplied sink or on a deep seal trap which is disconnected from the refrigerator by a distance of approximately four inches.

Drinking fountains connected directly to the sewer permit continuous passage of sewer gases into the surrounding atmosphere and offer an escape from the sewer of disease-bearing insects. Corrections for such faults are the same as those just mentioned.

Hastily constructed waste lines with poor connections are often

found in old buildings and allow leakage of waste water. This waste may find its way into the public water supply or seep into a privately owned open well or cistern. Such a condition also furnishes a harboring place for various insects and breeding grounds for mosquitoes. Inspection of old tenement houses will reveal these faults and correct plumbing can be installed.

Tile sewers close to open wells or cisterns have been known to leak and pollute same. Many city plumbing ordinances limit the proximity of tile sewers to a distance of 15 or 20 feet from open wells. Stone pipe or any similar drain pipe found in buildings should be replaced with cast iron pipe to prevent leakage.

If architects and designers of buildings with their plumbing fixtures could be impressed with the sanitary significance of improper plumbing installations to the point where they would demand that only safe fixtures be used, then manufacturers would cease to find sales for improper fixtures and fewer would be placed on the market.

The adoption of strict plumbing ordinances providing that only licensed and bonded plumbers be allowed to make plumbing installations will help eliminate the work of "amateurs" (close inspection and re-inspection of all plumbing (old as well as new) by a competent inspector will do much to eliminate the aforementioned plumbing faults and help protect the health of the people.

(Presented before the Southwest Section meeting, October 14, 1935.)

WATER RATES

By G. B. Schunke

(*Utility Accountant, Water Department, Seattle, Wash.*)

It is the purpose of this paper to discover and restate facts which may serve as a basis for a rate making structure. In other words, what does it *cost* to render water service.

The elements comprising this *cost* are as follows:

(1) Operating expense;

(2) Maintenance expense;

(3) Interest on funded debt;

(4) A proper and adequate reserve for depreciation.

The water rate structure must be adequate fully to compensate the utility for the outlays above enumerated.

In the ordinary human relations the *price* or *rate* of a commodity is fixed by the inexorable law of *supply* and *demand* and if this principle is tampered with we eventually end in a blind alley. In the case of a water utility, the *supply* being taken for granted, the *demand* is the factor that determines the proper rate to be determined to take care of elements of cost heretofore enumerated. In other words, our market is the amount of water that our citizens consume in their industrial and domestic capacity, and this must necessarily predetermine the rate which should be charged to recompense the water utility adequately for services rendered.

The writer does not wish to be understood as advocating a constantly changing base for a rate structure, subject to a variable demand factor, but this demand or load factor having been determined the rate may then be apportioned among the several users in proportion to the service rendered.

At the outset, this service should be measured. A municipal utility sells water, but some communities seem to think it should be rationed.

If there are any communities represented here that do not meter their supply to consumers, this paper will mean nothing to them. They can not possibly be interested, for an unmetered disposition of a water supply is merely a guessing contest in which the prudent, decent citizen is a victim penalized for the benefit of some one else.

We can all readily agree on the elements of cost involved. There will also be very little divergence of opinion with reference to the load or demand factor for the volume or turnover is just as decisive in determining a proper rate structure as in other lines of business. *The acid test of a proper water rate is the proper division or allocation of expenses to the several types of water users.* Collectively we must pay for all the expenses. But we do not make an equal demand for water. There is a vast difference between a man contracting for a ¾-inch supply of water and another demanding a 6-inch supply, as I shall presently attempt to point out. What the normal user contracts for is a supply of water through a ¾-inch pipe. He is entitled to the use of all the water that will pass through a ¾-inch pipe. He may use it only 1, 2 or 5 percent of the time, but the utility is under contract to furnish him water 100 percent of the time.

The same principle holds true of the consumer contracting for a 1-, 2- or 6-inch or larger supply, and the liability of the utility extends as fully to the larger consumer as to the smaller one, with this essential distinction—the larger the service, the greater the liability.

It follows therefore that the initial charge or rate for water service should be based on the relative liability that the water utility assumes, irrespective of whether or not the consumer uses any water at all. This represents what is commonly called the "ready-to-serve" charge. It represents the expenses that the water department must incur to have available any supply at all. This "ready-to-serve" charge is frequently misunderstood. The term has been in disrepute with the public because of the fact that private utilities in other fields used the term as a screen to gouge the public in the matter of rates.

However that may be, the water utility rate, in order to do justice to every consumer, must be broken up into two parts:

(a) "Ready to serve" or demand charge;

(b) "Consumption" or delivery charge.

The "demand" portion of the water rates represents that portion of expense required to *maintain* pipe lines, pumping stations, reservoirs, filtration plants, trunk and distribution mains, which must be maintained in order to give service if and when required. It also includes interest on the funded debt and depreciation. Furthermore this "demand" portion of the rate should be allocated against all the

consumers alike in direct proportion to the relative capacity of service applied for.

Assuming that a $\frac{3}{4}$-inch service is the unit of calculation, we have this result:

SIZE OF SERVICE, INCHES	RATIO	CAPACITY FACTOR
$\frac{3}{4}$	$\frac{9}{16}$	1.00
1	1 to $\frac{9}{16}$	1.77
$1\frac{1}{2}$	$2\frac{1}{4}$ to $\frac{9}{16}$	4.00
2	4 to $\frac{9}{16}$	7.11
3	9 to $\frac{9}{16}$	16.00
4	16 to $\frac{9}{16}$	28.44
6	36 to $\frac{9}{16}$	64.00
8	64 to $\frac{9}{16}$	113.77

It logically follows therefore that the demand portion of the water rate of a 6-inch tap would be 64 times that of a $\frac{3}{4}$-inch service.

So much for the demand charge.

The second portion of the rate results from the "consumption or delivery" charge.

When the consumer uses water operating expenses are incurred. Pumping plants must be operated, meters must be read, bills mailed and collected. The plant must be kept in service at all hours of the day and night to meet any eventuality that might occur. This represents the cost of operating or delivering the water service to the consumer.

To recapitulate, the water rate, to be scientifically correct, and in order to do justice to all alike, should be based (1) on a demand charge; (2) on a consumption charge. Consolidating these two elements should establish a fair and just rate.

There may be other local factors which may have some bearing on this matter of rates. Where the utility itself finances all extensions, either from bond issues or from surplus revenue, there may possibly be a mitigating factor favorable to consumers using large quantities of water. If the utility is able to finance itself exclusively from surplus earnings, that fact in itself is evidence that the water rate is not based on *cost.* Hence the larger consumer of water contributes a greater proportion to this surplus and therefore is entitled to have this reflected in the rate he is required to pay. But where the utility is financed from bond issues for the general supply and the distribution system is assessed to the abutting property all con-

sumers are on an absolute parity with reference to the "ready-to-serve" or demand charge and therefore are entitled to pay the same rates for the *use* of water in small or large quantities.

Then again we find the urge for special consideration for special classes of users and it is not uncommon to grant a bonus to special groups as a concession for the establishment of industries. This may cause competition between several communities in an endeavor to induce an industry to locate in a given locality. The question of cost is then entirely subordinated and the water utility is used as a means of attracting patronage to the detriment of all other consumers. No water rate of a utility should be thus prostituted.

RATES IN SEATTLE

For 28 years we had been operating under a water rate in Seattle which in the aggregate met all of our reasonable requirements. But the rate was not properly balanced. It was not a just distribution, particularly as it related to "private fire protection."

In order to change this condition we had to establish a "ready-to-serve" charge as outlined in this paper, or a modified "ready-to-serve" charge, permitting a nominal amount of water, based upon the size of the water service connection. The latter we were able to accomplish, although the former would have been the correct method of attacking the problem.

By re-arranging the water rate we have effected a reduction from 50 to 45 cents a month for the smaller consumer, but assessed a "demand" charge on a type of service that formerly did not pay its just share of expense.

We established the following schedule of rates for a month or fractional part thereof:

SIZE OF SERVICE, INCHES	CUBIC FEET OR LESS	DOLLARS
$\frac{3}{4}$	500	0.45
1	700	0.60
$1\frac{1}{2}$	1,400	1.00
2	2,200	1.50
3	3,900	2.50
4	5,600	3.50
6 or larger	8,100	5.00

If we would have been able to follow through, our minimum demand charge should have been higher on 3-inch services and up.

The amount of reduction effected for the smaller consumer was approximately $50,000.00 per year, which was redistributed against the larger type of service which previously had escaped its fair share of contribution.

It should be remembered that a municipal water utility is a "mutual" enterprise. The service rendered should be adequately compensated, but each consumer should pay his fair share, no more, no less.

DISCUSSION

F. FORD NORTHRUP: Mr. Schunke has given us the principles for establishing water rates. He has particularly stressed that the rates must be equitable among the various classes of customers and that they bring in enough revenue to cover all the costs of the service. These are the fundamentals, and cannot be criticised, and what I might say would be largely supplementary, opinions I have acquired through about ten years' experience in the study and adjustment of water and electric rates in Eugene, Oregon.

The water rates in any city cannot usually be greatly altered in their structure without a storm of protest from individuals or groups who may believe they are being discriminated against. The changes that we feel are essential must come through slight and frequent modifications.

As an aid to long distance planning of water department finances and rates, a proper organization is a great aid. A water commission separate from the tax collecting and money spending activities of a city council is a great help in keeping the water department free from political influence and to operate it on sound business principles.

The main business principle is this: "Pay for all services received, and to receive payment for all services rendered."

In the application of this principle the department will be self-supporting from revenues; will render no free service; will plan for debt retirement; and make plans for future needs of the system.

I have come to the belief that the operation of a municipal utility is a governmental function, operating for the benefit of all the customers, and not for the particular benefit of taxpayers and property owners. In changing rates, I would adjust them in the public interest according to the ability to pay, and the cost of service.

In receiving payment for all services rendered, the revenues should be from equitable rates. There are altogether too many glaring examples of gross inequity in rates. On the one hand there is the

case of large property owners who pay nothing for the water department's contribution to fire protection service—this service which protects his property and lowers his cost of insurance. And in another case we find the conscientious, frugal, small home renter who, through his high flat rate for water, pays for the protection of the business man's property, and what may be worse, pays for the wastefulness of his neighbor who will not keep his plumbing in repair; and also pays for the water used on the spacious lawn of the well-to-do man in the palatial residential district.

Beautiful homes, as desirable as they are, should be classed as luxuries. Lawn irrigation creates a heavy load on the system and runs up the cost of service, and it should pay its share of expense. I can see no valid reason for a municipal water system making a rate for summer use that is lower than for the same amount of water in winter.

There is one ridiculous contrast as to electric and water rates as we usually find them. In electric rates we find that electricity consumed at the time of peak load must pay a higher rate, due to the higher cost of service used at that time, and nobody questions it, whether the service is a necessity or luxury. In water rates, we find that especially low rates, even free water in the case of some flat rates, are given for irrigation at the time of greatest strain on the water system to deliver water.

Then there is what I call the psychology of rate making. We can see that there should be a "ready-to-serve" charge that is separate from the *use* of water. But customers are not mindful of utility financing; they believe they are buying water. So, in setting up a minimum charge, I would make it high enough to include a reasonable amount of water.

In a discussion of rates we are forced, by lack of time, to limit ourselves to generalities. I recommend that you file away all reference to these problems as found in the leading water works magazines and The *Journal*. You should have a copy of "Water Works Practice," the manual issued by the A. W. W. A. In the manual a discussion of charges for private and public fire protection will be found. A discussion as to rates for private fire protection will be found in the Round Table section of Water Works Engineering August 23, 1933.

I agree heartily with Mr. Schunke that the acid test of a rate is the proper division of expenses to the several types of users. This is more important than exact cost of any particular part of the service.

Probably two rate experts working separately would not agree very closely, as to the proper "ready-to-serve" charge for a Eugene residential customer with a ⅝-inch meter. They would probably start to solve the problem from different assumptions. One may figure the cost on the basis of total plant cost per customer, and the other figure only on the cost of the meter and service line plus a small amount of main.

So, equity is the principal item. While still maintaining equitable rates, cannot we also simplify them. I doubt if any of our Northwest cities can show cause for as many as fourteen price steps in their rates. The manual of Water Works Practice recommends three steps: the first 3300 cubic feet at a price per 100 cubic feet to be determined for each city; the next 30,000 cubic feet at a lower price; and all excess at a still lower price. But the cost per 100 cubic feet of the first step not to be more than twice the third and last step. What do you think of it?

If your rates are low because of some favorable circumstances, it is all right to compare rates with other cities, as this may be the easiest way to satisfy the home customers. If they are higher than others, do not cut them for that reason alone, for your are selling a service, not a commodity like flour or shoes, which sell for about the same price in neighboring cities. What you probably need to do is to find out why the difference and explain the difference to your water commission, city council, and customers. Even with the best of explanations and arguments you will still have to trust to Dame Fortune that the rate structure will not bow to expediency and snap judgment.

Take the city, for example, which has an unlimited lake supply at the city limits, requires no long gravity line, needs no filtration, and is just at the right elevation to require no pumping or reservoirs. Suppose the cost of mains, meters and service pipes were charged to abutting property, and meters read quarterly. Do you believe that your town could sell water as cheaply as that city? About the only capital expense such a city would have might be a small charge to replace mains that were too small or worn out.

In conclusion, the answer to the problem of water rates is a constant study of the principles involved, and application of them as opportunity affords, always forward, never backward, toward the goal of equity among customers, and I might add, simplicity.

(Presented before the Pacific Northwest Section meeting, May 15, 1936.)

SOCIETY AFFAIRS

PACIFIC NORTHWEST SECTION MEETING

The Ninth Annual Meeting of the Pacific Northwest Section was held at Aberdeen, Washington, with headquarters at the Hotel Morck with 146 registered.

The morning of May 14 was taken up by a golf tournament at the Grays Harbor Country Club, which was well participated in by the attendants.

In the afternoon of this day a Round Table Discussion was held under the leadership of Harold D. Fowler, Superintendent of the Water Department, Seattle, Washington. This feature of the annual meeting is being more enthusiastically participated in with each succeeding meeting. The subjects discussed were:

1. Joint material for cast iron mains.
2. Gate valve and hydrant inspection.
3. Protective paint for standpipes.
4. Collections and delinquent accounts.
5. Billing and records, Tap records, etc.

The meeting was especially fortunate to have present at this session the President-elect of the American Water Works Association, William W. Hurlbut of Los Angeles, California. The annual business meeting, with Chairman C. C. Casad presiding, was held in the evening at which time the report of the Secretary-Treasurer Ernest C. Willard was presented. Inasmuch as this report marked the close of a period of seven years of service in this capacity, some space was devoted to reviewing the past history of the Pacific Northwest Section, the preliminary organization meeting of which, was held on November 11, 1927.

This report showed a membership of 97 to which should be added one additional member whose membership card was not received until after the presentation of the report. The report also showed the Section to be in good financial standing. The Secretary also read a communication from President Barbour relative to the changes which were being made in the New York headquarters, acting upon the recommendation of the General Policy Committee, reference also being made to communication received from P. S. Wilson, Acting

Secretary and resolutions adopted by the Four-States Section, New Jersey Section, etc. After considerable discussion by President-elect Hurlbut and National Director Hughes the following resolution was unanimously adopted:

Resolved: That the Pacific Northwest Section go on record as standing squarely back of and approving the recent action of the General Policy Committee.

The report of the tellers showed that the following officers and trustees of the Section had been elected:

Chairman, A. H. Labsap, Water Superintendent, Longview, Washington.

Vice-chairman, M. H. McGuire, Manager McMinnville Water and Light Department, McMinnville, Oregon.

National Director (hold-over), W. P. Hughes, City Engineer and Water Superintendent, Lewiston, Idaho.

Secretary-Treasurer, Fred Merryfield, Assistant Professor of Civil Engineering, Oregon State College, Corvallis, Oregon.

Trustee, Harold D. Fowler, Superintendent Water Department, Seattle, Washington.

Trustee (hold-over) John W. Cunningham, Consulting Engineer, Portland, Oregon.

Invitations were received from Victoria, B. C., Medford, Oregon, and Centralia, Washington inviting the Section to hold its 1937 meeting in these cities and in accordance with the usual practice these invitations were referred to the incoming Board of Trustees.

There being no further business to come before the Section at this time, the meeting was turned back to Harold D. Fowler who again presided over the adjourned Round Table Discussion, the following additional subjects being discussed:

1. Meter repairs, inspections, and records, Service pipe connections and taps.
2. Location of water mains and service connections.
3. Cross-connections in water system.

In the morning of Friday, May 15 an address of welcome was given by Hon. Herbert Horrocks, Mayor of Aberdeen, which was replied to by the Chairman of the Section C. C. Casad, after which papers were presented as follows:

1. "P.W.A. Projects in Washington," by E. R. Hoffman, Acting State Director.
2. "Aberdeen Water System," by S. C. Watkins, City Engineer

and Water Superintendent, Aberdeen, Washington, with discussion by John W. Cunningham, Consulting Engineer, Portland, Oregon.

3. "Water Rates," by G. B. Schunke, Utility Accountant, Water Department, Seattle, Washington, with discussion by F. Ford Northrup, Eugene Water Board, Eugene, Oregon.

At this session it was moved, seconded and unanimously carried that the Section go on record endorsing the appropriations for the P.W.A., and letters were sent to the president of the United States, the senators from Oregon, Washington, and Idaho, the leading congressmen from the same states, to Harold Ickes, Secretary of Interior, the National Headquarters of the American Water Works Association, and the state directors of the Public Works Administration in the three states.

At the afternoon session a paper entitled "Reconstruction and Extension of the Green River Gravity Water System, Tacoma, Washington" was presented by W. A. Kunigk, Superintendent Water Division, Tacoma, Washington, which was discussed by W. H. Powell, Engineer Vancouver Water District, Vancouver, B. C. A paper entitled "Watershed Protection and Control" was presented by G. M. Irwin, City Engineer and Water Commissioner, Victoria, B. C., which was followed by a paper entitled "Cost of Fire Protection in a Water System," by Sydney J. Benedict, Asst. Engineer Bureau of Water Works, Portland, Oregon. The closing paper entitled "Business Principles of Sound Municipal Utilities Management" was presented by J. W. McArthur, General Superintendent-Secretary Eugene Water Board, Eugene, Oregon.

In the evening a large banquet was held, 148 being present, followed by an entertainment. The new officers were introduced and the meeting was addressed by William W. Hurlbut, President-elect of the Association. The retiring Secretary, Ernest C. Willard was presented with a combination barometer and thermometer in recognition of his service during the past seven years, the presentation speech being made by Ben S. Morrow, formerly National Director and Chief Engineer and General Manager of the Bureau of Water Works, Portland, Oregon. With the presentation of the gold prizes by J. L. Boyle and Albert H. Hooker the meeting adjourned.

The closing day, Saturday, May 16, was left open intentionally, so that those in attendance could arrange trips to the various points of interest.

FRED MERRYFIELD,
Secretary-Treasurer.

ABSTRACTS OF WATER WORKS LITERATURE

FRANK HANNAN

Key: American Journal of Public Health, 12: 1, 16, January, 1922. The figure 12 refers to the volume, 1 to the number of the issue, and 16 to the page of the journal.

A Note on the Methylene Blue Reduction Test for Differentiating between Coli and Aërogenes Types of Lactose-Fermenting Organisms in Water and Feces. T. N. S. RAGHAVACHARI and P. V. SEETHARAMA IYER. Ind. J. Med. Res., 23: 463–6, October, 1935. History of use of methylene blue as indicator of biochemical reduction is reviewed briefly. LINDSEY and MECKLER (J. Bact., 23: 115–21, 1931) reported that when drop of saturated aqueous solution of methylene was added to 24-hour culture of *B. aërogenes* in lactose broth indicator was reduced in few minutes, while in similar *B. coli* culture no visible reduction occurred in several hours. They found this test to agree with results of VOGES-PROSKAUER reaction in 44 out of 45 cases, but there were several discrepancies when it was compared with methyl red test. WILSON (J. State Med., 41: 46, 1933) secured similar results in glucose-peptone water medium containing 1 cc. 1 percent neutral red [per liter?] and 0.5 percent sodium citrate, *B. coli communis* producing red color and *B. lactis aërogenes*, yellow-green fluorescence. Authors applied LINDSEY-MECKLER test to over 2,000 cultures obtained from water and feces. Only 2 of 1273 coli cultures reduced methylene blue, but over 52 percent of aërogenes cultures and nearly 80 percent of intermediate forms failed to reduce the indicator. Reduction required at least 5 or 6 hours in most cases. Source of culture did not influence result to any marked degree. Concluded that test is nearly specific for *B. coli* but not for *B. aërogenes* and intermediate forms.—*R. E. Thompson.*

A Note on an Unusual Source of Contamination of Well Water. T. N. S. RAGHAVACHARI. Ind. Med. Gaz., 71: 80, February, 1936. During past 12 months, esthetic quality of water from deep well constructed in 1931 showed progressive deterioration, although chemical quality did not appreciably change. Water assumed dirty brown color; dirty-green algae developed on brick wall, together with definite oily coating in places, and there was distinct odor of petrol or kerosene. Investigation disclosed that 4 years ago considerable leakage of petrol had occurred from underground storage tanks of petroleum company located about 100 yards from well. Although dye tests failed to establish fact, old leakage from petrol tanks is believed to be source of contamination. Experiments indicated that treatment with alum, lime, and powdered activated carbon would render water suitable for drinking purposes.—*R. E. Thompson.*

A Comparative Study of Certain Selective Media Used in Water Analysis Together with a Review of the Literature on the Subject. T. N. S. RAGHAVACHARI and P. V. SEETHARAMA IYER. Ind. J. Med. Res., 23: 619–66, January, 1936. (Reprint.) This admirable paper consists of comprehensive, painstaking review of literature on *B. coli* test, brief outline of standard tests employed in various countries, statement of results of comparative tests with certain media on water from sources representative of different climatic and geological conditions and seasonal variations obtaining in Madras Presidency (area 150,000 square miles), and discussion of same. Extensiveness of literature review is indicated by fact that references given total 141. Media study consisted of comparing standard and non-standard media given in A. P. H. A. Standard Methods with each other and with MACCONKEY bile salt lactose broth, the routine medium in use at King Institute. Confirmation procedure consisted of subculture on MACCONKEY's bile salt lactose neutral red agar, transfer of 6 to 10 discrete pink colonies to bile salt lactose broth, and subsequent transfer to nutrient broth for microscopic examination and to differential media for classification of cultures into *B. coli*, *B. aërogenes*, and intermediates, which has been found of great value in interpreting results of examinations. Literature is cited to show that there is a growing conviction that *B. aërogenes* and intermediate forms are of little or no sanitary significance. In first series of tests, standard lactose broth was compared with MACCONKEY's bile salt lactose broth. Of 86 samples, 74 gave positive presumptive tests in lactose broth, 60 of which confirmed, while 74 were positive in bile salt broth, all of which confirmed. Percentage confirmation for different types of waters in case of lactose broth was as follows: raw waters 96; well waters 81.5; filtered waters 78; chlorinated waters 50. Results of differential tests based on methyl red and indole reactions and on citrate and indole tests are given. Latter combination gave perfect correlation and is therefore considered by authors to be very well suited for differentiation purposes. Percentage of true *B. coli* recovered was higher in case of bile salt broth on basis of all samples, but was higher for lactose broth when filtered and chlorinated samples only are considered. Latter is discounted by authors owing to fact that fewer confirmed positives were obtained with lactose broth on treated waters, i.e., 23 compared with 28 from bile salt broth. Lactose broth and brilliant green bile were compared on 45 samples, number of presumptive positive and confirmed tests being 39 and 34, and 38 and 33, respectively. On same set of samples 37 were presumptive positive in bile salt broth, all of which confirmed. Percentages of true *B. coli* were 43.2 from lactose broth, 50.7 from brilliant green bile, and 55.2 from bile salt broth. As in earlier series, percentage of true *B. coli* isolated from treated waters was higher with lactose broth than with brilliant green bile. About 45 percent more species of colon-aërogenes organisms were isolated from bile salt broth cultures than from brilliant green bile cultures. It is therefore concluded that former medium is definitely more selective for group in general and for true *B. coli* (as judged by coli isolations given above) in particular. In further series of 40 samples, SALLE's crystal violet broth was compared with lactose broth, number presumptive positive and confirmed in each, respectively, being 27 and 22, and 31 and 26. True *B. coli* were isolated from

52.9 and 59.0 percent of fermenters, respectively. In similar series of 54 samples, 36 were presumptive positive in SALLE's medium, of which 32 confirmed, while 35 were positive in bile salt broth, all of which confirmed. True *B. coli* isolations were 50.2 and 66.2 percent, respectively. As in case of lactose broth, crystal violet broth gave better results with treated than with raw waters. Previous studies (RAGHAVACHARI and SEETHARAMA IYER. This JOURNAL, 26: 1287, 1739) indicated that bile salt is more sensitive and reliable than DOMINICK-LAUTER methylene-blue-brom-cresol-purple broth and that EIJKMAN test is unreliable for Madras waters (WEBSTER and RAGHAVACHARI, Ind. J. Med. Res., 21: 525–9, 1934). Authors conclude that MACCONKEY's bile salt lactose broth is "the medium of choice in routine water bacteriology." It is sensitive and selective and enables accurate estimation of degree of pollution to be made in 24 hours without necessity of confirmation. During 25 years' use at King Institute there have been very few occasions when test failed to correlate with sanitary survey. Trouble with spurious fermenters has never been experienced. The composition of the medium, etc., is shown in the following table:

STRENGTH OF MEDIUM	MEDIUM PER TUBE	AMOUNT OF SAMPLE	NUMBER OF TUBES INOCULATED
	cc.	*cc.*	
A. Bacto peptone 6 percent	7	20	1
Sodium taurocholate 1.5 percent			
Lactose 1.5 percent			
Neutral red 1.0 percent			
pH 7.4–7.8			
B. 50 percent of A	7	10	2
C. 50 percent of A	5	5	3
D. 33.3 percent of A	3–4	1	3
		0.1	3
		0.01	3
		0.001	3

Final concentration of bile salt after addition of sample is 0.3–0.4 percent. The bile salt used is commercial sodium taurocholate, as advocated by MACCONKEY in 1900. Addition of 1 percent sodium chloride (double strength broth) as given in recent (1934) report (No. 71) of British Ministry of Health is not practised.—*R. E. Thompson.*

The Performance and Testing of Centrifugal Pumps. J. SMELLIE. Water and Water Engineering, 373: 443, 19–24, January, 1935. Performance curves of centrifugal pumps show relation between discharge, head, speed, and power. Tests and characteristic curves are given for four typical centrifugal pumps. Personal experience proves that use of reliable suction and pressure gauges is invaluable. If test be made at any time and performance curves plotted, pressure gauge readings alone will check pump and pipe line condi-

tion at any subsequent date. Pipe friction is often surprisingly high. Gross pumping inefficiencies should not pass unnoticed when simple and effective checks are easily obtained.—*W. G. Carey.*

Chemical Experiences with Small Water Supplies. J. W. HAWLEY. Water and Water Engineering, 37: 448, 268–269, May, 1935. Bromide test with fluorescein and bleaching powder is very delicate and might be applied for testing for infiltration by adding bromide to suspected infiltration water and then testing supply for bromide. Methods of protection of shallow wells are described, contamination by metals being avoided by filtration through limestone, or addition of limestone to well. Cases are described of metallic contamination caused by temporary acidity after heavy rain, and by water remaining in long pipes supplying remote buildings. Algal growths were removed by applying copper sulphate to spring water before pumping to storage tanks.—*W. G. Carey.*

Water Supplies from Underground Sources. J. D. RESTLER. Water and Water Engineering, 37: 447, 205–210, April, 1935. Importance is stressed of geological and engineering investigations in dealing with water supplies in order to ensure quantity and quality of water, its protection from undesirable supplies in neighbourhood, and suitability of strata for well sinking. Underground supplies have many advantages over surface supplies, e.g., absence of surface contamination, absence of growth in mains as when unpurified surface water is pumped any distance, uniformity of temperature, so that rapid contraction and bursting of mains is avoided. Sinking procedure for large and small borings, lining tubes, etc. are then described.—*W. G. Carey.*

Quabbin Reservoir Work Now in Full Swing. KARL R. KENNISON. Water Works Eng., 88: 18, 1062, September 18, 1935. In diversion of the Ware-Swift supply, a tunnel 25 miles long, one of the longest in the world, was built. Construction of Quabbin Reservoir, of Boston Metropolitan District, is notable for its average depth and size. Ten towns will be partly submerged, three towns eliminated, and 39 square miles will be flooded. Reservoir will be three times as large as New York City's largest. It will have a shore line of over 150 miles, and is one of most unusual reservoirs ever to have been built.—*Lewis V. Carpenter.*

Uses of Sources of Water Supply for Recreational Purposes. ARTHUR D. WESTON. Water Works Eng., 88: 19, 1070, September 18, 1935. Massachusetts Department of Public Health has adopted rules and regulations for purpose of preserving from pollution most surface sources of supply. They prescribe limits for location of burial grounds, sewers, hospitals, and of certain manufacturing establishments and provide that nobody shall bathe, or wade in, enter, boat upon, or fish in, any source of supply, except by special permit granted by Board of Water Commissioners. When certain microscopical organisms impart fishy tastes or odors, the layman places pressure on Water Commissioners for permission to fish, so as to prevent this taste. The number of fish has never been excessive. Protection of the watersheds

is responsible for low typhoid death rate (less than 0.5 per 100,000 in 1931). In 1913, as result of allowing fishing in a source of water supply in Massachusetts, there ensued some 1500 cases of enteritis within a period of 24 hours. People in that State demand water free from pollution and the regulations are not difficult to enforce.—*Lewis V. Carpenter.*

Surface Supply Gives Aberdeen Softer Water. Blaine Rowlee. Water Works Eng., 88: 19, 1072, September 18, 1935. Author describes development of surface supply of 5-grain hardness to replace 45-grain artesian supply. Impounding reservoirs were constructed as part of a municipal park development, with city selling summer home sites on reservoir banks. Water supply is partially softened and filtered.—*Lewis V. Carpenter.*

Selecting the Source of Supply. M. Z. Bair. Water Works Eng., 88: 19, 1078, September 18, 1935. Outlines in detail steps necessary to insure that water supply will be adequate and of satisfactory quality, both for domestic and industrial use, keeping always in mind factor of future population growth. —*Lewis V. Carpenter.*

Legal Rights of Water Employees. Leo T. Parker. Water Works Eng., 88: 19, 1083, September 18, 1935. Various courts have held that any attendant obscurity, or lack of good faith, suffices to invalidate dismissal from office of a civil service employee. Many courts have held that a municipal employee automatically forfeits his seniority rights, if he voluntarily resigns a civil service position, although he accepts other employment with the city. An employee of Department of Water and Power of Los Angeles was for a number of years a meter reader under civil service regulations. He was appointed by the city to another position which was not under civil service and after two years was appointed to another job which was under civil service. Courts held that he had forfeited his seniority rights when he accepted the position which was non-civil service. It is well-established law that neither a city official, nor other municipal employee, may recover payment for extra services, irrespective of the character of the work, if a city ordinance provides that the salary which he accepted is in full payment for his services. Courts have held that an employee is not required to submit to a dangerous operation, under penalty of forfeiting his right to compensation under State Compensation Laws. They have also ruled that a municipal employee is entitled to compensation for an occupational disease, and they recognize as such, any disease attributable to the prolonged exercise of his occupation. Generally speaking, a municipality is not liable, either under the common law, or compensation laws, for disability sustained by any person, unless the party claiming compensation proves to court's satisfaction that at time when injury occurred, he was actually in the employ of the city.—*Lewis V. Carpenter.*

Sale of Surplus Water by Cities. Leo T. Parker. Water Works Eng., 88: 20, 1136, October 2, 1935. Various courts have held that if a municipality owning and operating a water plant has an excess of water beyond the requirements of the public, sale of such excess to outside consumers is incidental

exercise of legitimate powers. Several courts have ruled that it is not legal for a city to construct mains outside the city for the purpose of supplying water to consumers not in the corporation limit. Unless state laws clearly forbid municipalities to sell water to outsiders, city may sell its surplus, provided it is not required to spend money incidentally thereto. If state law authorizes a municipality to extend its system outside corporate limits, it may then extend its system within the limits as defined by law. Frequently private water companies enter into contracts with property owners, under which latter deposit money to guarantee against losses arising from extension of water system. The law is well settled that where the water company subsequently sells the system and plant to the municipality, latter may automatically assume the obligations of the water company.—*Lewis V. Carpenter.*

Diesel Engine Exhaust Used in Water Softening. PAUL STEGEMAN. Water Works Eng., 88: 21, 1182, October 16, 1935. The 200-pound Diesel engine of Midland, Mich., plant, used to generate electric current, serves further to supply (1) hot water for slaking lime, various laboratory purposes, wash room, and shower bath; (2) heat for heating building; and (3) carbon dioxide for recarbonation of lime-softened water. Carbon dioxide content of exhaust gases is about one-half that of producer gas; but it carries no objectionable taste so that scrubbing is not required. During winter of 1934–35, no coal was purchased for heating, heat from exhaust gases proving sufficient. First year's operation of new Diesel showed a saving of 38.4 percent on the power bill, when savings on recarbonation and heating accounts were duly accredited. —*Lewis V. Carpenter.*

Russian Water Supply Systems. V. E. KOJINOR. Water Works Eng., 88: 22, 1934, October 31, 1935. Methods are described of pipe line laying and of structural construction in a country where the ground is frozen to a depth of 65 to 230 feet. Summer thawing seldom exceeds 10 to 12 feet. Water mains must be laid in frozen ground and water heated before pumping. Some water can be obtained from artesian wells, but most of it has to come from surface rivers or from melting ice.—*Lewis V. Carpenter.*

A New Device for Locating Hidden Pipes. S. C. HOARE. Water Works Eng., 88: 23, 1298, November 13, 1935. Device is a surveying compass, with an adjustable bar magnet for purpose of reducing control effects of earth's magnetic field, and increasing susceptibility to magnetic disturbance produced by the pipe. Affixed to compass box, and turning with it as a unit, are two radial fins of high permeability, low hysteresis, magnetic material, which serve as magnetic antennae. The detector is sensitive both to iron and to steel pipe and works better if a small current is passed through the pipe. It has a remarkable record on the lines that have been used for test purposes.—*Lewis V. Carpenter.*

Novel Hydro-Electric Control. HAROLD VAGTBORG. Water Works Eng., 88: 24, 1346, November 27, 1935. Plant at Shenandoah, Iowa, is so arranged

that each of two filters is preceded by separate recarbonating basin and sedimentation tank. Flow between the three units is over weirs, so that intermediate valves are not needed. A hydraulically-operated valve is placed on influent line to sedimentation tank. Location of valves prohibited operating table of standard type. Valves are opened or closed by a fractional horse-power electric motor: valve position is indicated by galvanometer on control table. Instalment of emergency lighting system in water works plant having valves hydro-electrically controlled renders operator completely independent of power supply and water pressure. This will require use of Universal motors and emergency connection of circuit to the emergency lighting system.—*Lewis V. Carpenter.*

Legal Rights of Water Users. Leo T. Parker. Water Works Eng., **88**: 24, 1352, November 27, 1935. Municipality is liable for any damage to private property resulting from negligent operation of its Water Department. If property holder complains about a leak, city must correct it immediately. Case is cited where city was held liable in damages because nearly a year elapsed after first complaint before city located the leak. Courts have consistently held that fire protection service rendered by city to its inhabitants is a gratuity. It is well established that municipality's fire extinguishment service is a governmental function, and not a matter of legal right, and that city is not liable for refusal, or failure, to render it effectually, or at all. One case is cited where a contractor, during construction, broke a main which city should have fixed in two hours; cut city took 9 hours, during which time a house burned which could have been extinguished with water. Court held the contractor liable, in spite of negligence of city in repairing main. Author reviews the well-known laws of riparian owners which have been in effect for a number of years.—*Lewis V. Carpenter.*

Spring in the Air. Nathan N. Wolpert. Water Works Eng., **88**: 23, 1294, November 3, 1935; **88**: 24, 1349, November 27, 1935; and **88**: 25, 1910, December 11, 1935. Author makes a thorough survey of all of the most commonly used systems of air conditioning, with special reference to effect on water consumption. All of the leading systems are described and their water requirements given. The R.C.A. Building in New York recirculates all the water, excepting some makeup. One 5-and-10-cent store used 32,800 cubic feet each day, which was equivalent to a population load of 2500 people. The small water company might be embarrassed by the additional load. Article includes much technical information which should be of interest in air-conditioning field.—*Lewis V. Carpenter.*

Gold Rush Town's Water Plant. T. A. Bither. Water Works Eng., **88**: 26, 1462, December 25, 1935. Descriptive article on the water company of Carson City, Nevada, which was organized in 1860. In 1874, a steel pipe line 10,000 feet in length was constructed, which remained in service until 1935. Pipe had a riveted 6-inch sleeve on each end and lead was poured around this sleeve. This line was recently renewed with 12-inch spiral welded pipe. All field joints were electrically welded, using a portable electric generator set.—*Lewis V. Carpenter.*

Iron and Hard Water Problems Solved at Waupun, Wis. H. T. Rudgal. Water Works Eng., **88:** 25, 1404, December 11, 1935. Success has been achieved by a one-million-gallon softening and iron removal plant, using the excess lime method. Water contains 1 p.p.m. of iron and 300 p.p.m. of hardness, of which only 34 p.p.m. is non-carbonate. Plant has both rapid and slow mixing, mechanical clarifiers, carbonation basin, and filters. Saving in soap has amounted to $1.80 per capita annually, which is more than the annual per capita cost of operation of the plant.—*Lewis V. Carpenter.*

Water Contracts vs. State Laws. Leo T. Parker. Water Works Eng., **88:** 26, 1470, December 25, 1935. Courts have held that State Public Service Commission has power to revise existing rates, even if they had been agreed upon by parties involved at an earlier period. Rate, even if it is reasonable, might with lapse of time have become discriminatory. Higher courts have consistently held that when contract does not contain a stipulation as to how long it shall remain in force, then either contracting party may cancel it by giving the other party reasonable notice. At different times, courts have held that property owner cannot recover from water works company damages for fire loss occasioned by failure of such company to furnish, in accordance with its contract with city, sufficient water to extinguish the fire. Various courts have held that neither a city, nor an individual tax-payer, may file suit and recover payment from a water company, or other public utility company, unless state law specifically authorizes filing of such suit. A specific law is necessary to enable a water company, whether public or private, to establish a lien on property to secure payment on water bills. It is well-known that under ordinary circumstances a state law is void which interferes with interstate commerce; but state laws are enforceable which require installation of water accessories, equipment, etc., by licensed plumbers, although sale and delivery of such is an interstate transaction.—*Lewis V. Carpenter.*

Damages for Water Pollution. Leo T. Parker. Municipal Sanitation, **6:** 7, 215–216, 221, July, 1935. Notwithstanding numerous circumstances under which municipality may be liable in damages for polluting water, Courts frequently render verdicts favorable to municipalities, particularly when evidence introduced convinces the Court that allowance of damages, or granting an injunction against further polluting acts, is not justifiable. The questions (1) whether Court will hold city liable in damages for sickness, or death, of inhabitants, where only circumstantial evidence is relied upon to prove that such sickness, or death, resulted from drinking polluted water; and (2) whether municipality is relieved from liability for sickness or death of its inhabitants, caused by polluted water, where state statute creates a state health board with subordinate county and city departments; were decided in late case of Safransky *v.* City of Helena, Helena, Montana, 39 Pac. (2d) 644. Case facts given. It is well settled that Courts will render verdicts with view to safeguarding health of persons exposed to disease hazards through drinking polluted water. Yet injunction against existing method of sewage disposal will not be granted, if testimony indicates that no immediate danger is to be apprehended and that proper and adequate plans are being completed to

eliminate all future danger to health of complaining citizens, or other persons. Town of Smithfield *v.* City of Raleigh, 178 S. E. 114. Case facts given. **Legal Effect of Injunction.** All municipal officials should realize disadvantages of permitting an injunction to issue against city for any reason. Party who obtained the injunction may, at a subsequent date, file suit for damages, in which event, testimony proving that injunction had been previously issued may assist complaining party to obtain a favorable verdict against city. HEALDTON *v.* Regnier, 39 Pac. (2d) 973. Case facts given. **What is Governmental Function?** Frequently, municipalities disclaim liability for injury to persons and private property, resulting from water polluted by the city, contending that maintenance and operation of sewerage system is a governmental function. It is well known that municipal corporation is not liable for injuries to citizens, resulting from negligence of its officers when engaged in performance of a governmental function. Moreover, various courts have held that maintenance of public parks and playgrounds, and construction and maintenance of drains, ditches, and sewers by municipalities are governmental functions. On the other hand, it is important that courts have held that municipalities are liable for damages to private property caused by creation or maintenance of nuisances, whether in performance of their governmental, or of their proprietary functions, to same extent as are private persons. HODGES *v.* Town of Drew, 159 So. 298. Case facts given. **Damage Distinctions.** It is well established law that where the market value of private property is depreciated as result of water pollution, the owner is entitled to judgment for damages. If, however, the property owner sues for permanent damages and can prove only temporary damages, court may reject his claim. In other words, complaining party is bound to prove that which he alleges. So held higher Court in MARTIN *v.* Continental, 39 Pac. (2d) 917. Case facts given. **Definite Proof is Essential.** In all legal controversies involving pollution of a water supply, in order that complaining party shall recover damages for alleged pollution, conclusive proof is necessary that water was polluted by party against whom suit is filed and, also, that damages actually were effected by that pollution. On the other hand, law does not require that complaining party prove the exact quantity of material which has been introduced into the water, alleged to be polluted, as such essential facts may be decided by the jury in rendering judgment for damages. —*R. E. Noble.*

Stream Pollution and Stream Purification. ABEL WOLMAN. Municipal Sanitation, 6: 3, 71, March, 1935. Author briefly discusses control of stream pollution and its legal, administrative, and financial aspects.—*R. E. Noble.*

City Held Liable for Typhoid Fever Contracted from Drinking Water. Public Health Reports, 50: 15, 525–526, April 12, 1935. (Montana Supreme Court; SAFRANSKY *v.* City of Helena, 39 P. (2d) 644; decided Jan. 3, 1935). Action was brought to recover damages from city of Helena, plaintiff alleging that he had contracted typhoid fever as result of drinking contaminated city water. Lower court held city liable; finding sustained by higher court. Court opinion given in part.—*R. E. Noble.*

Bacteriological Examinations of Oysters and Water from Narragansett Bay during the Winter and Spring of 1927–28. L. M. Fisher and J. E. Acker. Public Health Reports, 50: 42, 1449–1475, October 18, 1935. (1) From study of samples from shellfish growing areas, it is apparent that water quality is better in winter and early spring than in late fall. (2) Oyster quality tends similarly and perhaps even more markedly to improve with season. Oyster results are, however, likely to be more erratic, in that occasional excessively high scores may occur rather frequently. (3) During marketing season, general tendency in northern oyster-growing areas is for scores to increase, or decrease, according as water scores increase, or decrease. In individual comparisons, however, differences may be extreme. (4) Marked improvement in oyster quality consistently occurs within about 1°C. of the freezing point. 13 tables, 5 charts, and 1 diagram.—*R. E. Noble.*

Three States Join in Plan to Control Pollution of Waters. Municipal Sanitation, 6: 9, 273, September, 1935. Concerted movement by New York State, New Jersey, and Connecticut to secure $300,000,000, or more, principally from Federal Works Progress Administration funds, in order to terminate pollution of waters in the metropolitan area, was agreed to on August 15 at conference of Interstate Sanitation Commission in New York City. Latter body was ready to spend $100,000,000 to end pollution, provided that New Jersey and Connecticut municipalities corrected their sewage disposal systems. Program given of procedure for ending pollution.—*R. E. Noble.*

Detroit Prepares Large Improvement Program to PWA. Municipal Sanitation, 6: 4, 122, April, 1935. Detroit, Mich., submitted to the State Planning Commission proposals covering projects for water purification and for sewage collection and treatment, cost being estimated at $14,610,080.—*R. E. Noble.*

Principles of Sanitation and Hygiene for a Correctional Institution. M. R. King. Public Health Reports, 50: 6, 181–190, February 8, 1935. Article outlines sanitary code for correctional institutions and includes recommendations for inspection of waste disposal facilities and of water supply.—*R. E. Noble.*

Sanitary Engineers Discuss Cross-Connections. Municipal Sanitation, 6: 10, 296–298, October, 1935. At thirtieth annual convention, held in New York, of American Society of Sanitary Engineering, prominent topics of technical discussions included the following. (A) New York's dangerous pollution of coastal waters. Enormity of problem is envisaged. Tidal waters are burdened with total discharge from sewered population of 12,000,000, of whom 70 percent are located in New York, 25 percent, in New Jersey, and 5 percent, in Connecticut. Sea cannot remove these wastes: only 5 percent of tidal flow is fresh water, and sewage oscillates along the polluted shores. Condition of sludge deposits was described and gradual creep of muck toward near-by beaches was shown. Recently formed Inter-State Sanitation Commission, which will take up work of protecting coastal waters from pollution, was lauded. (B) Sanitation problems, including sanitary control of water

supply, swimming pools, sewerage facilities, and plumbing systems were discussed by health officers. (C) Utilization of sewers for garbage disposal. (D) Condemnation of plumbing cross-connections. Conditions capable of causing siphonage were listed as follows. (1) Water pressure failure in buildings, districts, or suburbs, caused by: (a) breaks in water mains; (b) fluctuations in pressure above and below atmospheric; (c) improperly designed, or undersized, water piping in house; (d) development outstripping supply in isolated districts; (e) heavy demands in extended dry periods; and (f) fire pump connections "hogging" all the water. (2) Turning off of water supply at foot of pipe risers in cases of stoppage. (3) Turning off of water in basements in emergencies. (4) Turning off of water at individual fixtures. Resolution was adopted that Association would no longer meet in hotels which could not supply certificate of freedom of plumbing from cross-connections. Report of committee urged higher standards in plumbing inspection and higher calibre in personnel. (E) Society's continued sanitation research along many lines. (F) Relationship of water supply to air conditioning. Present trend toward control of temperature and humidity in homes, offices, and public buildings, foreshadowing consequent considerable increase in use of water, is causing many communities to study the probable ultimate effect of this beneficial control of environment on water supply problems.—*R. E. Noble.*

Bacterial Purification Rates in Polluted Water. J. K. Hoskins. Public Health Reports, 50: 12, 385–404, March 22, 1935. General conclusion is that bacterial reduction consistently observed is due chiefly to activity of bacteria-eating plankton. Except for presence of predatory plankton, environment existing even in moderately polluted waters is sufficiently favorable to permit considerable bacterial multiplication, at rates varying with temperature. Decrease in bacteria usually observed in polluted streams is to be interpreted as difference between their rate of multiplication and their rate of destruction by foraging plankton. Any disturbance of balance between plankton and bacterial population alters rate of change in the latter; and since this balance is in constant process of readjustment, rate of bacterial decrease is constantly changing and, not infrequently, direction of change is temporarily reversed. Most favorable conditions for rapid bacterial reduction are met where highly polluted water, rich in bacteria, passes over an attached, stationary plankton "carpet." Physical factors tending to increase the rate of bacterial destruction by bringing about this biological condition are (*a*) increase in proportion of wetted area to volume, and (*b*) turbulence, promoting contact with the biological carpet and aëration. Natural streams exhibit all grades of variation with respect to these conditions, ranging from deep, sluggish channels, with minimum proportion of wetted surface area to volume, up to broad, shallow riffles such as occur in trickling brooks. Correspondingly wide variation seems to occur in natural purification rates from the low values observed in deep broad rivers to the extremely rapid rates occurring in sewage trickling filters. It is probable that dominant physical factor in these different rates is relationship between volume of flow and wetted area of the channel cross section. The view that attached plankton, on bottom and margins of stream

channel, play a large part in bacterial destruction, explains the increase in bacteria which is observed when polluted river water is removed from the stream and stored in laboratory containers. Such storage, in effect, temporarily eliminates all plankton-covered wetted surfaces and at same time produces, perhaps, other minor changes in environmental conditions to which the plankton require a certain time to become adjusted.—*R. E. Noble.*

Are We Going to Clean up Our Streams? (Editorial) ABEL WOLMAN. Municipal Sanitation, **6**: 6, 171, June, 1935. Author briefly discusses stream pollution under following aspects: (1) technical solutions; (2) Federal or State action; (3) trade waste treatment and cost; and (4) public interest.—*R. E. Noble.*

Typhoid Fever Bacilli in Sewage. (Editorial) ABEL WOLMAN. Municipal Sanitation, **6**: 8, 233, August, 1935. Stresses the danger of sewage contamination in drinking water. Recommends further studies in special media for typhoid isolation. Development of specific tests for pathogenic organisms in sewage and perhaps in water, should not, however, result in any lowering of present sanitary standards, which have proved a real safety factor, as shown by lower typhoid fever incidences.—*R. E. Noble.*

Federal Committee Sets Forth Plans for Nation-Wide Pollution Abatement. Municipal Sanitation, **6**: 11, 332, 340, November, 1935. Special Advisory Committee on pollution makes six definite recommendations for clearing up stream pollution from coast to coast. Recommendations given.—*R. E. Noble.*

Investigation of Pollution of Bathing Beach Waters. H. LEE NELSON. Municipal Sanitation, **6**: 11, 329–332, November, 1935. Article covers 1933 (summer) investigation at Kingsland Point Park. Includes location, sampling methods, surface current studies, laboratory methods, and current conditions; with bacteriological findings. Charts give B. O. D. and D. O. values. Graph shows chlorination effects.—*R. E. Noble.*

Town Can be Held to Respond in Damages for Injuries Resulting from Disrepair of Septic Tank. Public Health Reports, 50: 43, 1501–1502, October 25, 1935. (Mississippi Supreme Court, Division B; HODGES et ux. *v.* Town of Drew, 159 So. 298, decided Feb. 11, 1935.) Action was brought to recover damages for injuries to plaintiffs' health and comfort and to their land, alleged to have been caused by the improper and negligent maintenance by defendant of its septic tank. Trial court held for defendant; plaintiffs appealed. Evidence showed that town permitted septic tank to fall into such disrepair that sewage overflowed and contaminated surrounding land and waters of a near-by lake. Septic tank and lake, in part, were situated on plaintiffs' farm. Offensive and nauseating odors were emitted by overflowing sewage. Defendant contended (*a*) that evidence failed to show that plaintiffs suffered any peculiar or special damage on account of maintenance of the nuisance not common to the general public, and (*b*) that in construction and maintenance of the waterworks system, including the septic tank, town was in the

exercise of its police power of conserving the public health, a governmental function, in exercise of which, although wrongful, town was not liable for damage to property. Supreme court reversed the judgment and remanded the cause.—*R. E. Noble.*

Fixing Liability for Water Pollution. Leo T. Parker. Municipal Sanitation, 6: 3, 81–82, 85, March, 1935. Rule is well settled that any one who sustains damage may have relief against a public nuisance and is entitled to maintain a suit at law for damages on account of the special injury which he has sustained. When a water supply is damaged and polluted by a substance percolating through the soil, owner of that water supply may maintain an action for damages against owner of land from which the substance escaped, if it is readily apparent that pollution has resulted. Above holds, even if others may have contributed to the injury. Therefore, it seems reasonable and just that a person, who has something on his own property harmless to others while confined to his own property, should be obliged to make good the damage which ensues if he fails to confine it. For these reasons, under certain circumstances, a municipality may be relieved from liability and the person, or company, who originates the cause of water pollution is liable, although the polluting substance is placed under control of the city. This law was upheld in the case of Berry *v.* Shell Petroleum Co., 33 P. (2d) 953. Case facts. City officials advised oil companies in a near-by field that salt water produced by their wells endangered the city water supply and park system. City then permitted oil company to pipe salt water effluent to city sewer, which emptied into a river south of the city. A property owner sued to recover damages and proved that by reason of the soil nature, the salt water percolated into and under his property, polluting wells and other sources of water supply. Oil companies contended that damage was caused after it had released the water into city control, and in accordance with city demands. Higher Court held the oil companies liable. Court decision given in part. **Percolating and Subterranean Streams.** Law is well established that owner of land bounding on a surface stream may not pollute the same to the impairment of the use and enjoyment of stream by other riparian owners. Moreover, this rule applies to subterranean streams which follow a known or readily ascertainable course. Another important rule is that a person, or company, who brings on his land and collects and keeps there anything likely to do mischief if it escapes, on the surface, must keep it confined at his peril, and is *primâ facie* answerable for all damage which is the natural consequence of its escape. However, he can escape liability by showing that escape was due to the complaining party's default, or that it was the consequence of an act of God. So held higher Court in case of Rose *v.* Socony-Vacuum Corporation, 173 Atl. 627. Case facts: Refining company built upon its property a large number of storage tanks for petroleum and its products. Occasionally it permitted quantities of stored materials and refinery waste substances to escape on its land. These materials percolated into the ground and polluted water on adjoining land whose owners sued refining company to recover damages. Testimony indicated that refining company's employees were not negligent in permitting substances to escape; hence, because, furthermore, the course of percolating waters from its land to adjoining property was

not known, Higher Court refused to hold company liable. **Warrant Held Defective.** It is well settled law that a warrant charging water pollution must clearly define the act which is alleged to have resulted in the pollution. For instance, if an individual, or corporation, builds adequate tanks, or uses a building for storing oil, or other material, and a tornado sweeps their contents into a stream, this act would of necessity be positioning the polluting substance where it reached the water course; still no Court would hold upon such testimony that a law had been violated. There are many other conceivable ways in which polluting substances might reach a water course or a lake, when the causes were not such as could have been reasonably foreseen or prevented. Under these circumstances, Courts will not convict a person, or company, of violating a law forbidding polluting water, particularly if the petition, or warrant, charging the pollution does not clearly explain the acts which caused the pollution. This law was upheld in the late case of LESTER. *v* State, 71 S. W. (2d) 278. Case facts given. **Statutory vs. Common Law.** The law is well established that a state Legislature may pass a valid law that prohibits use of land for any purpose which under the rules of common law was held to be a public nuisance. JENKINS *v.* A. G. Tomasello & Son, 189 N. E. 817. **Must Prove Water Damage.** Courts have consistently held that city will not be held entitled to favorable verdict in suit against any firm, or person, who is charged with polluting water, or that such person cannot be criminally convicted, unless convincing testimony is introduced proving that the party actually polluted the water, or permitted the polluting substances to originate from his property. Decided in case of BRANN *v.* State, 37 P. (2d) 982. Case facts given.—*R. E. Noble.*

Can Boiler Explosions Due to Low Water Be Prevented? FRANK RUSSELL. Railway Age, **100:** 12, 499–501, 1936. On the Southern Pacific Lines, the locomotives are protected against overheated crown sheets and explosions due to low water by multiple application of boiler drop plugs. Objections to former type fusible plugs, with core of fusible metal, which often failed to give suitable warning, have been overcome in the drop plug, in which a brass plug is held in place by an annular ring of fusible metal. Head of plug, which is on the fire side, is also embedded in fusible metal. Free movement of plug, in case of low water, is insured. *R. C. Bardwell (Courtesy Chem. Abst.).*

Direct Delivery Pumps Eliminate Water Tanks. P. D. FITZPATRICK. Railway Engineering and Maintenance, **32:** 1, 31–32, 1936. Wayside water storage tanks have been displaced at some intermediate water stations on Grand Trunk Western Railroad with installations of pumping units for handling water direct from source to engine tender. Submerged impeller vertical centrifugal pump, with delivery of approximately 3000 gallons per minute, is used to raise the water from concrete intake well through 12-inch main to 10-inch delivery column.—*R. C. Bardwell.*

Cause of and Remedy for Pitting and Corrosion of Locomotive Boiler Tubes and Sheets, with Special Reference to Status of Embrittlement Investigations. R. E. COUGHLAN, et al. American Railway Engineering Association, **37:**

Bulletin 383, 399–400, 1936. Progress report listing characteristics and suggested remedies.—*R. C. Bardwell (Courtesy Chem. Abst.).*

Types of Lime and Soda Ash Equipment Used in Treating Water. H. E. Silcox, et al. American Railway Engineering Association, 37: Bulletin 383, 400–407, 1936. Railway Age, 100: 11, 443, 1936. Chemical proportioning equipment used by railroads include water motors, weir or orifice controls, and venturi tube or meter types. Chemical vats have either vertical or horizontal agitation. Typical installation plans are given showing facilities for pumping coagulant and repumping sludge.—*R. C. Bardwell (Courtesy Chem. Abst.).*

Water Conditions Affecting the Extension of Locomotive Washout Periods. J. B. Wesley, et al. American Railway Engineering Association, 37: Bulletin 383, 407–415, 1936. Railway Age, 150: 11, 442–443, 1936. Presence of excessive amounts of mud and deposition of scale of sufficient thickness to require bombardment of sheets for removal, are the only water conditions that affect the period between boiler washouts, provided that boilers are properly blown and handled. Operation of locomotives over extended washout periods by proper use of blow-off equipment has effected appreciable economies.—*R. C. Bardwell (Courtesy Chem. Abst.).*

Effect on Preservative in Treated Ties in Track Due to Blowing Off Locomotives on Line of Road. C. S. Burt, et al. American Railway Engineering Association 37: Bulletin 383, 530–533, 1936. Railway Age, 100: 11, 449, 1936. Tests made on the Nickel Plate and The Chesapeake and Ohio Railways developed that no appreciable increase in loss of creosote occurred in track ties subjected to hot water from locomotive blow-down, as compared with those not so exposed. Maximum recorded temperature in tests was 168°F. Temperature falls off after train has passed over blow-down location. It was concluded that method of blow-down as practiced does not cause material increase in loss of creosote from treated ties.—*R. C. Bardwell (Courtesy Chem. Abst.).*

The Water Works of Lancaster, Pa., on its One Hundredth Birthday. James J. Malone. Water Works and Sewerage, 82: 9, 297–302, September, 1935. Brief historical sketch of system is given. Rebuilt pumping station, distribution system, and filter plant are described. Pumps are all electrically driven. Chemical treatments include lime, alum, and carbon. After mechanical mixing, water receives two-stage settling, with mechanical sludge removal in first stage. After filtration, water is treated with chlorine and ammonia. Old slow sand filters were converted into aërators, for postaëration.—*H. E. Hudson, Jr.*

Spartanburg, S. C., Erects a 1,500,000-Gallon Elevated Storage Tank. R. B. Simms and J. K. Marquis. Water Works and Sewerage, 82: 9, 303, September, 1935. Elevated storage tank was installed to supplement inadequate existing elevated storage and maintain more constant pressure. Supply main, tank location, connections, and costs are discussed.—*H. E. Hudson, Jr.*

Anthrafilt Gives Longer Filter Runs Than Sand. H. G. TURNER and G. S. SCOTT. Water Works and Sewerage, **82**: 9, 308, September, 1935. Experimental equipment and procedure are described. Turbidities were determined photoelectrically. Data presented indicate that filter runs for anthracite are longer than for Ottawa sand of same screen size, and that anthracite produces clearer water.—*H. E. Hudson, Jr.*

World's Largest Water Treatment Plant Will De-silt Colorado River Water. ANON. Water Works and Sewerage, **82**: 9, 316, September, 1935. Irrigation water for Imperial Valley will be de-silted in 8,000-m.g.d. sedimentation plant equipped for mechanical silt removal.—*H. E. Hudson, Jr.*

"Tegul": a New Sulfur Jointing Compound for Bell and Spigot Pipe. C. R. PAYNE. Water Works and Sewerage, **82**: 9, 317, September, 1935. Description of physical properties of new jointing compound.—*H. E. Hudson, Jr.*

Water Requirements of Apartment Houses. W. M. RAPP. Waterworks and Sewerage, **82**: 9, 318, September, 1935. Data on consumption in apartment houses of various sizes in Atlanta, Ga.—*H. E. Hudson, Jr.*

A Study of Filtering Materials for Rapid Sand Filters. Part 6: Mud Ball Formation and Measurement: Miscellaneous Items. JOHN R. BAYLIS. Water Works and Sewerage, **82**: 9, 326–330, September, 1935. Observations on beds of various materials, washed to produce 50 percent expansion, indicated that filtering materials of specific gravity lower than silica sand accumulated more mud balls than heavier materials. Mud balls sank to sand-gravel interface in light materials, but not in heavy ones. Filtering materials heavier than sand promise greater freedom from mud ball formation and clogging troubles than lighter materials. Procedure for quantitative measurement of mud ball volume in filtering material is described. Four-month record of tests on 3 filters receiving different waters is given. Writer proposes as standard of filter bed condition, that mud ball volume should not be greater than 0.1 percent of sand volume in any part of the bed. Surface washing system to achieve this standard will usually not require an increase in total amount of wash water. Use of a layer of coarse material over a bed of finer material of higher specific gravity is a practical means of lengthening filter runs.—*H. E. Hudson, Jr.*

Inclined Diagonal Pipe Runs. CHARLES FRICK. Water Works and Sewerage, **82**: 9, 333, September, 1935. Formulae for figuring lengths of pipes and tie-rods on diagonal runs.—*H. E. Hudson, Jr.*

A Sand Rise Indicator. ANON. Water Works and Sewerage, **82**: 9, 333, September, 1935. Water-proofed flashlight attached to graduated view tube is lowered to expanded sand surface.—*H. E. Hudson, Jr.*

Blowing Out Service Lines. S. H. DAVIS. Water Works and Sewerage, **82**: 10, 344, October, 1935. Clogged service lines are blown out with compressed

air, using rock salt as scraping piston. Equipment is described and illustrated.—*H. E. Hudson, Jr.*

Corrosion Control With a Marble Filter. HARRY RYON. Water Works and Sewerage, **82**: 10, 360, October, 1935. Extremely soft water of high carbon dioxide content gave red water and corrosion troubles until treated by filtration through beds of crushed marble. Filters were designed on basis given by experiments.—*H. E. Hudson, Jr.*

Operations in the Jacksonville Water Meter Department. J. E. HERRING. Water Works and Sewerage, **82**: 10, 365, October, 1935. All meters in Jacksonville, Fla., are read monthly and tested when they are not registering, or when the bill is disputed. Maintenance and repair practise is given. Equipment and procedure for testing meters is presented.—*H. E. Hudson, Jr.*

Water Supply and Sewerage Disposal at Singapore, Straits Settlements. ISADOR W. MENDELSOHN. Water Works and Sewerage, **82**: 11, 371, November, 1935. Sources of supply are impounding reservoirs. Three filtration plants, two slow- and one rapid-sand, are used. Operating data are given with general description of operating practise. Filtered water is chlorinated. Considerable trouble was experienced with filter bed fouling in rapid-sand plant until more adequate pre-treatment of filter influent for iron removal was adopted. Sewage works, operating results and research are described. —*H. E. Hudson, Jr.*

Primary Elements for Sewage and Water Works Meters. L. D. CARLYON. Water Works and Sewerage, **82**: 11, 375, November, 1935. Discussion of principles, applications, and relative merits of Venturi, flow nozzle, and orifice meters, as used in measuring water, sewage, sludge, or air. Discussion also includes effects of (1) initial cost, (2) installation, (3) accuracy, (4) reliability, (5) pressure loss, and (6) capacity change, on selection of meter.—*H. E. Hudson, Jr.*

Forgotten Meters. EARL A. SMITH. Water Works and Sewerage, **82**: 11, 387, November, 1935. Writer urges regular periodic inspection, cleaning, and overhauling of water meters. Profits will result. Shop procedure is suggested. Comparison with gasoline engine maintainance shows that meters are unduly neglected.—*H. E. Hudson, Jr.*

Experiences in Water Main Cleaning at Evansville, Ind. CHARLES STREITHOF. Water Works and Sewerage, **82**: 11, 394, November, 1935. Cleaning of mains with hydraulically propelled device improved flow and pressure conditions. Work was done under contract by water main cleaning concern. Procedure, results, and costs are given. Cost averaged 19.6 cents per foot of pipe.—*H. E. Hudson, Jr.*

Handling Emergency Main Repairs. HENRY E. NUNN. Water Works and Sewerage, **82**: 11, 396, November, 1935. Discussion of preparations, crew

organization, adequacy and care of equipment, maintenance, and consideration of the consumer in connection with emergency repairs. Pointers on repair technique are given.—*H. E. Hudson, Jr.*

Improved Standards for the Residual Chlorine Tests. R. D. SCOTT. Water Works and Sewerage, **82**: 11, 399, November, 1935. Standards made of three parts potassium chromate to each part of potassium dichromate exactly matched the color produced by chlorine and *ortho*-tolidine. Standards must be buffered to hold within narrow pH range for proper color values. These standards are permanent and color values are correct for any desired depth of liquid.—*H. E. Hudson, Jr.*

Milwaukee's Water Purification Plant. L. R. HOWSON. Water Works and Sewerage, **82**: 12, 403–410, December, 1935. Brief history of Milwaukee water works, particularly of progress toward purification, is followed by complete description of purification plant, which is to have 200 m.g.d. capacity. Factors affecting design are discussed. Tunnel connections and sequence of operations in making them are described. Site of plant is 30-acre area in lake, enclosed by revetment wall consisting of a single line of steel sheeting, anchored by oak piling and buttressed by rock fill. Water will be taken from present Lake Michigan intake and, after filtration, will flow through existing tunnels to all-electrical pumping stations. Tunnel will have surge outlet 10 feet above lake level, together with storage tank to hold overflow. Water will be lifted from tunnel by 5 pumps having combined capacity of 275 m.g.d. The filter plant is to consist of 4 integrated units. Floc-forming chambers will be of "flocculator" type, with detention period of about 40 minutes, that of settling basins being about 4 hours. There will be 32 filters, each of 6¼ m.g.d. capacity. Clear water storage will total 29.6 m.g. Wash water tank is situated in a near-by bluff. An unusual feature of the design is two-story type of settling basin, adopted for its increased settling per unit area, ample depth being available, and structural, hydraulic, and layout considerations being favorable. Provision is made for future installation, when needed, of continuous sludge removal equipment. Filters are unusually large, and of central gullet type, with waste conduits located at end opposite from other manifolds. Gravel layer, which rests on perforated pipe underdrains, is 24 inches thick and sand, placed in two layers, 27 inches. Facilities are provided for feeding alum, lime, ammonium sulfate, activated carbon, liquid chlorine, and ammonia. Chemicals will be trucked to plant in special trucks, and handled within plant pneumatically. Table showing chemical storage provided is given.—*H. E. Hudson, Jr.*

An Improved Method for Rating and Sampling Wells. PAUL F. HOWARD. Water Works and Sewerage, **82**: 12, 422, December, 1935. Well rater and sampler is described, consisting of gasoline-driven centrifugal pump, hand priming pump, orifice meter with manometer, and drawdown manometer. Drawdown of well under usual pumping is first measured, and when same drawdown has been reached by use of portable pump, flow is measured and sample taken.—*H. E. Hudson, Jr.*

A Modern Turbidimeter. GRANT LAUGHLIN. Water Works and Sewerage, 82: 12, 423, December, 1935. Photoelectric turbidimeter described is equipped with two scales that enable reading of turbidities ranging from 0 to 3000. Device is calibrated against distilled water.—*H. E. Hudson, Jr.*

Dry Ice as Well Cleaner. Monsanto "Chemical Topics." Water Works and Sewerage, 82: 12, 423, December, 1935. By dropping 200 pounds of dry ice down a well casing, and then closing well tight, pressure is built up which reverses flow through screens and water bearing material surrounding screens, thus cleaning well.—*H. E. Hudson, Jr.*

Short Schools and Licensing. EDW. S. HOPKINS. Water Works and Sewerage, 82: 12, 424, December, 1935. Author believes that the work of national technical societies should be directed toward education of local appointing executives as to proper operator qualifications, rather than toward support of "bureaucratic" control through licensing by state agencies. Short schools cannot provide adequate training for complete responsible charge of operation of sanitary works; at least part time supervision by a highly trained man is urged. Task of short school is training of existing personnel, and keeping them in touch with new developments.—*H. E. Hudson, Jr.*

Sanitary Water Board of Pennsylvania Replies to Pittsburgh Resolution on Stream Pollution. Anon. Water Works and Sewerage, 82: 12, 426, December, 1935. Reply by Water Board of Pennsylvania to Pittsburgh suggestion that steps be taken to abate pollution in water supply source. Reply enumerates steps which have been taken.—*H. E. Hudson, Jr.*

The Cartographic Study of Drought. W. R. BALDWIN-WISEMAN. Quar. Jour. Roy. Met. Soc., 60: 257, October, 1934, pp. 523–532. The author uses the severe drought in Queensland, Australia in 1902 to illustrate a method of studying the extent and progress of drought conditions. The subject of aridity or, as it is sometimes called, "areology," presents an almost unexplored field in hydro-meteorology. Its importance is illustrated by the fact that in the Queensland drought of 1902, 2,800,000 sheep and over 1,200,000 cattle were lost and the yield of wheat dropped from 19.4 bushels per acre in 1901 to 3.3 bushels per acre in 1902.

The author's method of procedure consists in platting a map of percentage of rainfall deficiency separately for each month and drawing in isodefs or lines of equal rainfall percentage deficiency; also the boundary of the area of deficient rainfall. Somewhat similar methods have been applied to seasonal or annual total rainfalls heretofore. The particular advantage claimed for monthly plattings is that it shows the progress of drought conditions over a given area or region and the movement of drought centers from month to month. In the case under consideration the total area affected by the drought was much greater than the area affected in any single month. The author points out that to apply this method long rainfall records are desirable for the reason that it requires a much longer record to give correctly the mean rainfall for a given month than to give correctly the yearly mean. The author

suggests that whereas 30 or 35 years may give a close estimate of the long-term average rainfall, a record of 100 years or more might be required to give the means for individual months with equal accuracy. The total area affected by the Queensland drought was 628,000 square miles. The largest area affected in any one month was 384,000 square miles and the drought center migrated from south to north throughout a distance of something like 600 miles.—*R. E. Horton.*

The Secular Variation of Rainfall. W. R. BALDWIN-WISEMAN. Quar. Jour. Roy. Met. Soc., **61**: 262, October, 1935, pp. 427–434. This paper is a study of the relation of range of variation of rainfall to mean annual rainfall. It is based on an analysis of 1,114 rainfall records, each covering at least 30 years, of which about 50 percent were in Australia, 26.3 percent in North America, 10 percent in Europe, and the remainder in other countries. Twenty of the records examined had an average duration of 124 years each. The highest yearly and lowest yearly rainfall for each station were tabulated in conjunction with the mean, and group means obtained for all stations having mean rainfall within pairs of limits varying by 10-inch increments. A plat of the results shows that the relations between the highest and lowest yearly rainfalls and the mean are not linear, although roughly the lowest annual rainfall was found to be half of the mean, whereas the highest annual rainfall is considerably more than 50 percent greater than the mean.

Part of the paper is devoted to the interesting question of the length of rainfall record necessary to give an approximate true mean rainfall. Since a record of 35 years' duration is commonly assumed to be adequate, the author compared the mean rainfall for different 35-year periods with the mean of the entire record in case of several long records. He found in some cases that 35-year periods could be so selected as to give averages ranging from 11.7 per cent below to 13.6 per cent above the full record mean.—*R. E. Horton.*

NEW BOOKS

Proceedings of the Seventeenth Texas Water Works Short School, Austin, Texas, January 3 to 5, 1935. V. M. EHLERS, Secretary State Department of Health, Austin. 6 x 9 inches, paper, 190 pp. **Coöperation Between Universities and the Water Works Profession.** T. U. TAYLOR. 27–28. General discussion of problems of water and soil conservation in Texas. **Present and Future Status of P.W.A. Projects in Texas.** J. MONTGOMERY. 29–32. Analysis of projects completed and under way shows that Texas has fared well in the 1934 allotments. **Chemistry and Economies of Water Softening.** W. S. MAHLIE. 33–39. Explanation of the causes of hardness in water; practical methods of softening; and economy of softening as compared with the waste of soap and of compounds. **Water Treatment.** C. C. HEDGES. 40–42. Description of the functions of water treatment and of practical means for their accomplishment. **Chemical Control Tests for Water Treatment.** B. WARDLOW. 43–44. Discussion of the significance of tests for turbidity, hardness, alkalinity or acidity, and pH and of other tests employed for control of water treatment. **Chemistry of Corrosion.** G. M. CROOK. 44–48. Three main types of corrosion are self-corrosion, galvanic corrosion, and electrolytic

corrosion. Self-corrosion results from contact of a metal with moist air, or with water containing dissolved oxygen. Relationship of solution pressure to this type of corrosion is discussed. Galvanic corrosion results when two dissimilar metals are present in water and occurs most commonly where two types of pipe materials join. Electrolytic corrosion results from the passage of an electric current through and away from underground metals. Such currents are commonly induced by return ground currents of electric power and street railway systems. Treatment for corrosion involves the formation of protective chemical coatings on both metallic surfaces and removal of oxygen. Aëration and lime treatment are commonly employed. **The Chlorine Residual Test.** E. A. Cain. 48–51. Technique of the *ortho*-tolidin test and notes concerning interference with this test by nitrites, manganic compounds, and ferric compounds. **Determining the Effectiveness of Activated Carbon.** H. H. Arrant. 52–54. Threshold odor, iodine adsorption, suspensibility, moisture, ash, pH of water extract, and phenol adsorption tests are all available. Author suggests use of an activation number, determined as the quotient of the suspensibility divided by the adsorption. **The Rôle of Bacteria in Water-Borne Diseases.** J. S. Wooten. 55–56. The science of bacteriological examination of water is still in its infancy and much work remains to be done in this field. **Specifications for Main and Jute Sterilization.** J. W. Cunningham. 57–59. Contamination of pipe and jute before, during, and after laying may result in pollution of water supplies. Jute may be sterilized by live steam or by chemicals. Pipe should be thoroughly cleaned before laying, bulkheaded while in trench, and thoroughly sterilized after its final flushing. **Plumbing and Its Relation to Health.** F. M. Murphy. 60–63. Notes on historical development of plumbing, present status of the art, and problems of the future. **Status of Water Works in Texas.** J. W. Brown. 64–67. **Making of Water Rates and Fair Charges.** E. E. McAdams. 67–72. Nature of the supply, investment values in plant, consumption of water, wastage, and free water are all factors in the determination of rates. Rates should be sufficient to pay annual sinking fund requirement and interest charges on outstanding debt, to provide ordinary extensions, and to pay all overhead and operating expenses. Water rates of many Texas municipalities are analyzed. **Mottled Enamel Teeth and the Fluorine Factor.** Jack Wyatt. 73–77. Mottled enamel is a tooth defect characterized by dull chalky white patches over the surface of the teeth. Endemic areas occur in central Texas, Arizona, Colorado, New Mexico, South Carolina, North Carolina, California, Idaho, Kansas, Arkansas, Nevada, North Dakota, South Dakota, Washington, Oregon, Virginia, Oklahoma, Alabama, Utah, Mississippi, Tennessee, Minnesota, and Wisconsin. Circumstantial evidence indicates fluorine in water as cause. Several methods of analysis for this element are given. U. S. Public Health Service are now investigating problem in Texas. **Mottled Enamel.** C. A. McMurray. 78–81. Dentist's report on mottled enamel in Ennis, Texas. Prior to 1909, Ennis water supply was from lakes without fluorine and there was no mottling of tooth enamel of persons born prior to 1904. From 1909 to 1926 supply was from artesian wells with fluorine content of 0.9 p.p.m. Little or no mottling has occurred in persons using this supply during childhood. From 1926 to date a new well has served the town, with

water of fluorine content of 4.4 p.p.m., which has resulted in mottled enamel in practically every person using it during childhood. **Mottled Enamel.** R. F. NIX. 82–85. Dentist's report for Lamesa, Texas. In this town having a water supply carrying fluorine of 6.7 p.p.m., a census of high school children showed that every one born and living since birth in the vicinity had mottled enamel. **Irrigation Rates.** D. W. ROBINSON. 85–87. In many cities in which there is an increased demand for water in the summer months, special rates are allowed, usually involving an increased monthly minimum charge with an increase in water allowed, followed by one or more steps at low rates. **Program of Allied State Departments. I. State Board of Water Engineers.** CHARLES CLARK. 87–96. History of the development of Texas water legislation and work done and in progress under this Board. **II. State Reclamation Department.** A. M. [illegible]. 97–98. Administration of overflowed and swamp lands as carried out by this department. **Selection of Proper Power and Pumping Equipment for City Water Works.** J. B. DANNENBAUM. 99–102. Analysis of the many factors influencing the choice of equipment. **Water Supply Distribution Pipe: Method of Choosing and Economics.** A. P. HANCOCK. 103–105. Cast iron pipe mains and copper service lines recommended for small towns. **Control of Pipe Corrosion in Well Water Supplies.** C. E. TWEEDLE. 106–110. Waters low in pH must have $CaCO_3$ alkalinity artificially built up. **Operation and Maintenance of Fire Hydrants and Valves.** T. G. BANKS. 110–118. Oklahoma City has a well planned system of records of hydrant and valve locations and a well organized program of inspection and maintenance described in intimate detail. **Discussion** favors color scheme for identification of hydrants. **Purchase of Equipment and Supplies for Water Works.** W. W. MCCLENDON. 118–125. Standardization of materials and equipment and quantity purchasing in coöperation with other towns are advocated. A municipality should so far as possible eliminate the unknown factors from construction contracts. **Proper Sanitary Control of Water-Sheds and Surface Water Supplies.** A. M. Brenneke. 126–128. Point of intake and control of the stream immediately above are important considerations in the use of flowing streams. Adjacent water-shed of an impounding reservoir should be carefully controlled. **Stream Pollution as a Waste Disposal Problem in Texas.** V. M. EHLERS. 129–132. Solution of the problem must be approached through development of an effective system for retaining sewage plant operators, by the provision of more field personnel for State Department of Health, by strengthening the law relating to salt and tidal waters, by increased development of the practice of plant disposal of sewage, and by the provision of means for experimental study of sewage and trade wastes. **Water Supply Protection Through Legislation.** J. S. REDDITT. 132. Legislation must provide police powers for state and local departments of health. **Future Problems of Taste, Odor and Palatability. I.** A. H. DOUGLASS. 133–134. Future problem of water works operator will be that of keeping pace with progress and of adapting improved methods to his particular problems. **II.** L. O. BERNHAGEN. 135–137. Odors and tastes due to industrial waste, domestic sewage, plankton forms, and bacterial action can be eliminated by proper application of one of a number of available remedies. **What the Texas Relief Commission Has Done to Meet the Water Supply Emergency in the**

Recent Drought. E. A. BAUGH. 138–142. Eighty-five new wells drilled; fourteen existing wells rehabilitated; and much other work done to meet emergency conditions. **Chemical Precipitation of Sewage.** E. W. STEELE and P. J. A. ZELLAR. 143–148. **Sedimentation and Chemical Precipitation.** W. F. HICKS. 148–149. **Status of Activated Sludge Litigation.** J. H. PAINTER. 150–155. **Preliminary Studies of Brewery Wastes.** W. S. STANLEY. 155–158. **Construction and Progress in Sewage Plant Design.** H. R. F. HALLAND. 158–163. **Experience with Sewage Farming in California.** E. H. REINKE. 163–164. **Sewage Irrigation in Texas.** E. H. GOODWIN. 165–169. **Sewage Irrigation.** H. G. NICKLE. 170–171. **Operation of Small Town Sewage Treatment Plants: Imhoff Tanks.** H. D. MCAFEE. 171–173. **Primary Sedimentation and Separate Digestion as Applied to Small Town Conditions.** R. M. DIXON. 174–176. **Dunbar Beds.** R. C. RATLIFF. 176–179. **Operation of Small Town Sewage Treatment Plants; Activated Sludge Plants.** G. B. GASCOIGNE. 180–186. **Manufacturing, Testing and Use of Diffuser Mediums.** F. C. ROE. 186–190.—*R. L. McNamee.*

Report of Eleventh Annual Missouri Water and Sewage Conference, Columbia, Missouri, November 22–23, 1935. R. R. STEWART, Secy. State Board of Health, Jefferson City, Missouri. 8½ by 11 inches. Mimeo. 51 pages. **Water Purification Problems.** E. E. WOLFE. 1–3. Some of the perplexing problems of water purification involve training of personnel, corrosion, tastes and odors, filter bed maintenance, and identification of *B. coli*. **Filtration Plant Operation and Improvements.** J. A. BOYER. 4–8. Account of changes in plant and operation methods at Maryville, Missouri, plant. **Notes About Maryville, Missouri, Water Purification Plant.** O. L. ROBEY. 9. **Prechlorination of a Turbid Water Supply.** G. F. GILKISON. 10–12. Prechlorination with ammoniation at Kansas City, Missouri, water purification plant greatly reduced the bacterial load on filters and on post-chlorination. **Chemical Precipitation Sewage Treatment Plant at Kahoka, Missouri.** FRANK BEARD. 13–18. **Water and Sewerage Improvements at Bolivar, Missouri.** F. L. STEWARD. 19–20. City has secured complete system of sewers and sewage disposal and water main extensions and an elevated tank under P.W.A. financing. **The Biology of Sewage Disposal.** T. C. MILLER. 21–25. **The State Department of Health Laboratory in Its Relation to Water and Sewage Problems.** C. F. ADAMS. 26–31. Outline of adequate personnel and equipment required in a state laboratory, in order properly to perform its function in relation to public health. **Public Works Program in Missouri.** E. C. M. BURKHART. 32–35. Résumé of public works construction carried out under 1932-3 P.W.A. financing. **Sewerage Improvements at Springfield, Missouri.** RALPH FUHRMAN. 36–38. **Abstracts of Papers, 10th Meeting, October 15–16, 1934.** Following subjects: **Effects of Droughts on Water Supplies; Tracing Underground Water Flows; Shooting Wells to Increase Production; Bacteriologic Control of Water Purification Plants; Meter Maintenance; Collection of Delinquent Accounts; Recarbonation of Lime Softened Water; Taste and Odor Control; Handling Customer's Complaints;** and **Demonstration of Simple Water Tests** are covered by brief abstracts. **The Proper Construction of Well Water**

Supplies. H. S. McQueen. 44–48. Missouri practice in control of municipal well construction by State Board of Health and State Geological Survey. Specifications provide for samples of cuttings, length and weight of casing, sealing, water analyses, and logs of wells.—*R. L. McNamee.*

Vom Wasser; Ein Jahrbuch fur Wasserchemie und Wasserreinigungstechnik, IX Band: 1935. 96 pp. Verlag Chemie, G.m.b.H., Berlin. W. 35. **Utilization of Domestic Sewage by Irrigation.** Kreuz. 13–21. Available phosphoric acid, nitrogen and potash in sewage are in ratio 1:2:3, which is suitable as fertilizer for fodder; it is best to apply sewage as artificial rain during growth and by irrigation at other times. **Domestic and Industrial Sewage as Artificial Rain.** G. Schonnopp. 22–30. Pre-treatment consists of screens, sand-traps, and, if necessary, settling tanks before use as fertilizer. **Standardization of Operation and Cost Data of Artificial Rain Plants.** E. Weise. 31-35. Artificial rainfall of 200 millimeters per annum is taken as basis and calculations and data obtained from Berlin plants are given. **Inspection of Sewage Irrigation in the Delitzsch District.** L. W. Haase. 36–39. Deals with disposal of part of Leipzig's sewage by irrigation. **Sewage Treatment in Fishponds.** A. Schillinger. 40–46. Fishponds are efficient in sewage treatment, but three times as much dilution water is required. Rate of flow should be slow enough to avoid plankton loss; oxygen content and pH of pond are important. **Utilization of Waste Waters Containing Oils and Fats.** A. Heilmann. 47–56. Grease recovery from sewage is discussed. **Utilization of Effluents from Sugar, Starch, Cellulose, Paper, and Textile Industries and from Breweries.** H. Haupt. 57–69. Describes composition and uses of effluents from above. **Utilization of Sludge and Other Materials from Effluents of Coal Washing Industries.** A. Weigmann. 70–86. Methods in use for economic recovery of coal sludge from coal dressing plants, and coke slack from coke quenching plants are described. Phenol is present in some by-product works in sufficient amount to be worth recovering. **Utilization of Wastes from Tanneries and Slaughter Houses.** R. Van der Leeden. 87–94. Sulphur recovery is not an economic process; recovery of chromium entails large plant; blood is best kept separate from other wastes and dried.—*W. G. Carey.*

Cross Connections in Plumbing and Water Systems. By A. A. Kalinske, F. M. Dawson and Frank R. King. This bulletin is the second edition with important changes and revisions over the one issued by the authors in 1934. The information contained in it is based on studies and tests made at the University of Wisconsin during the last six years. Because of its thoroughness of text and excellent presentation of principles and practices through well prepared illustrations it should be in the library of every engineer, architect and plumber.

It is especially complete in its treatment of back siphonage in plumbing systems and fixtures in homes, industrial plants, hospitals and institutions. Ways and means of correcting faulty connections are described and illustrated.

The bulletin also contains a map of the state of Wisconsin showing the

types of public water systems; requirements of the Wisconsin State Board of Health regarding cross connections and plumbing fixtures; a copy of the Wisconsin Plumbing Code and a description of an exhibit prepared by the Wisconsin Board of Health and the State University showing pollution of water supplies by cross connections through plumbing fixtures.

Copies of the bulletin are obtainable free to citizens of Wisconsin and by others at a charge of $0.25 for single copies and $0.20 in lots of five or more, by writing the Wisconsin Board of Health at Madison.—*A. E. Gorman.*